NEARSHORE FISH SURVEY IN THE WESTERN BEAUFORT SEA
HARRISON BAY TO ELSON LAGOON

by

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Final Report

Outer Continental Shelf Environmental Assessment Program

Research Unit 631

June 1983

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INTRODUCTION

Prior to the development of the petroleum industry, fisheries surveys in the Alaska Beaufort Sea were few and limited in scope. Most of these early surveys (Murdock 1885, Bean 1891, Anderson 1951, Wohlschlag 1954, McPhail 1966) provided new range extensions and some described new species; however, the areas covered were limited to large rivers, deltas and subsistence fishing grounds. More recent fisheries surveys (Kogl and Schell 1974, Bendock 1979a, Craig and Haldorson 1981, Craig and Griffiths 1981, Griffiths and Gallaway 1982, Gallaway and Britch 1983) have increased the understanding of anadromous fisheries resources in the Beaufort Sea, especially those areas east of the Colville River. These studies have been stimulated in part by the high petrochemical interests in areas of the mid- and eastern Beaufort, especially near Prudhoe Bay. More recently an accelerated lease-sale program initiated by the current administration in the Department of Interior has shifted interest to areas west of Prudhoe Bay encompassing the nearshore areas between Harrison Bay and Point Barrow. Fisheries studies in this area are limited.

Frost et al. (1978) conducted marine demersal fish surveys in offshore waters of the Beaufort Sea, Hablett (1979) conducted a two-year fisheries survey of lakes, streams and rivers within the NPR-A including several sites near the Beaufort coast; and Craig and Griffiths (1981) surveyed areas of Harrison Bay near Thetis and Eskimo islands (Figure 1). These surveys provided significant new fisheries information for selected areas of the western Beaufort Sea, however to date no broad synoptic surveys have been conducted in the nearshore estuarine and marine waters. Clearly a need existed for initial fisheries surveys in this area of the Beaufort Sea.

Study Area

The western Beaufort Sea, including areas from the Colville River delta to Barrow, encompasses several types of coastal habitat. Some

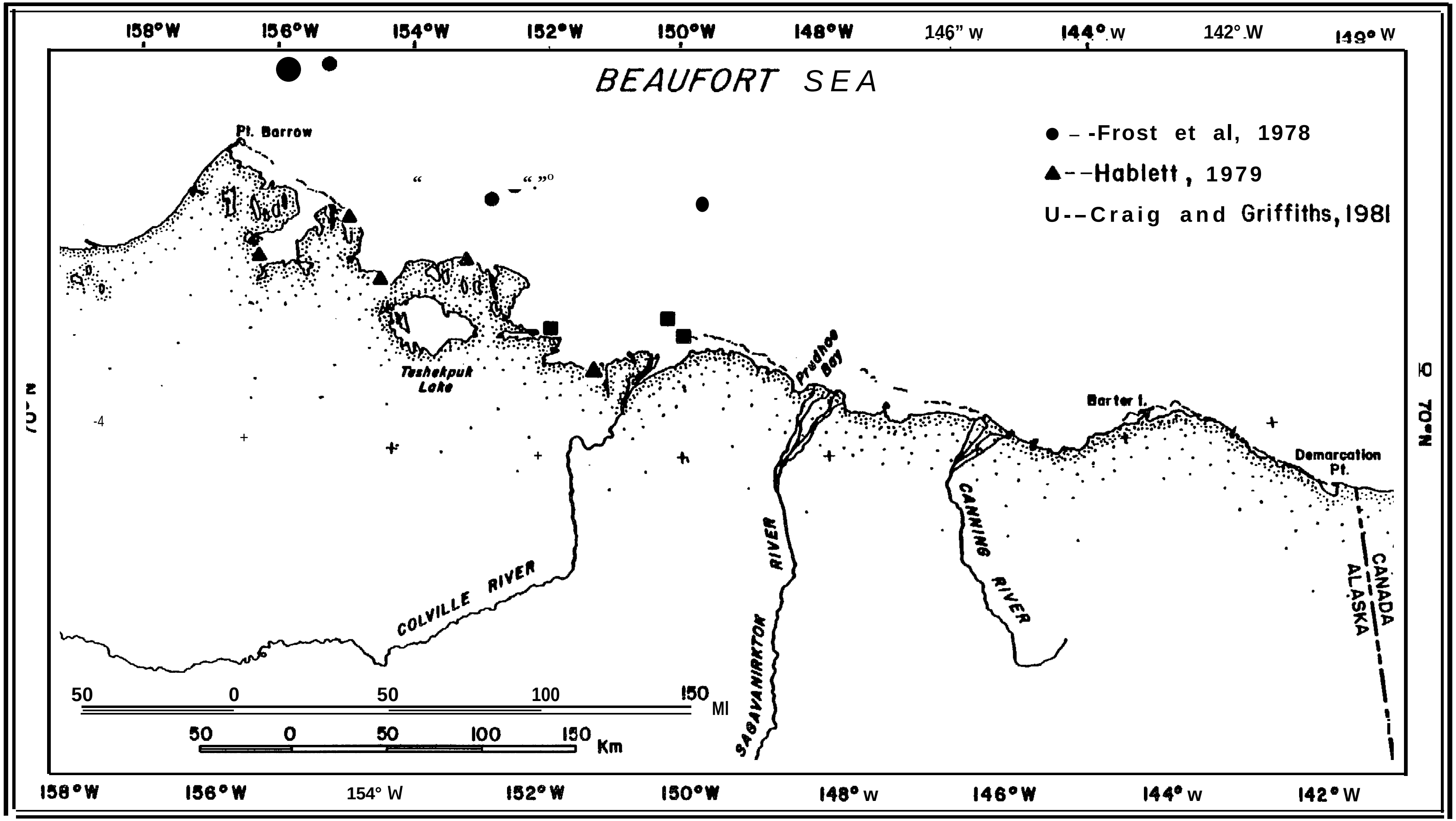

Figure 1. Sampling site locations in the western Beaufort Sea prior to the 1982 survey (after Frost et al, 1978: Hablett, 1979; Craig and Griffiths, 1981).

areas, such as Harrison Bay and Dease Inlet are typified as large protected embayments with variable but low salinities (Naidu and Mowatt 1975) usually resulting from breakup conditions and riverine influence (Walker 1974) . Limited areas of this coastline including Elson Lagoon are lagoons protected by barrier islands. These lagoons, as others (Craig and Haldorson 1981), have variable salinities depending upon riverine input and meteorological conditions. Finally, areas such as Pitt and Pogik points represent unprotected shoreline. Dominant conditions here include variable, moderate to high salinities, relatively low water temperatures and frequent strong currents and high waves.

The western Beaufort coastline, when viewed as a whole and compared to the eastern Beaufort, contains fewer barrier island-protected lagoons but more large bays. These two areas also differ in coastal zone habitat. The western Beaufort is influenced by several slow-flowing, tundra rivers (e.g., Colville, Meade and Ikpikpuk rivers) and numerous smaller tundra streams. Comparatively, streams and rivers in the eastern Beaufort are montane in origin, and have relatively clean and fast flowing water. Many of these streams are spring fed and provide over-wintering habitat (Craig and McCart 1974, Craig 1977). The western Beaufort zone also contains numerous small and large tundra lakes, including Teshekpuk Lake, which may provide overwintering habitat for whitefish. To date the role that this large lake plays in influencing coastal fisheries is unknown.

METHODS

Fish sampling in the western Beaufort Sea was conducted from 23 July to 7 August 1982. Fish were captured in gill nets 30.5 m long and 1.8 m deep with three equally-sized panels with mesh sizes of 2.5, 5.1 and 7.6 cm (stretched). The nets were buoyed and weighted such that the lead line would set on the bottom and the float line would be at or near the surface. Nets were set from shore and perpendicular to it with the largest mesh being the most seaward. Net set locations illustrated in Figure 2, were reached by float plane and the nets were set by wading offshore and anchoring the seaward end. On two occasions, when the water depths exceeded 1.3 m, the nets were set from the floats of the airplane as it taxied from shore. Nets were typically set for 24 h, however, several sets were longer due to inclement flying weather.

Originally a benchmark net was to be set and run daily at Cape Halkett, however, large quantities of peat in the nearshore area precluded effective gillnetting. An alternative site was selected at Eskimo Island. The survey progressed from east to west by first running the benchmark net, then running a second net which was then pulled and moved to a new location farther west. The following is a list of the net locations with a brief description of the site including map coordinates (Orth 1971):

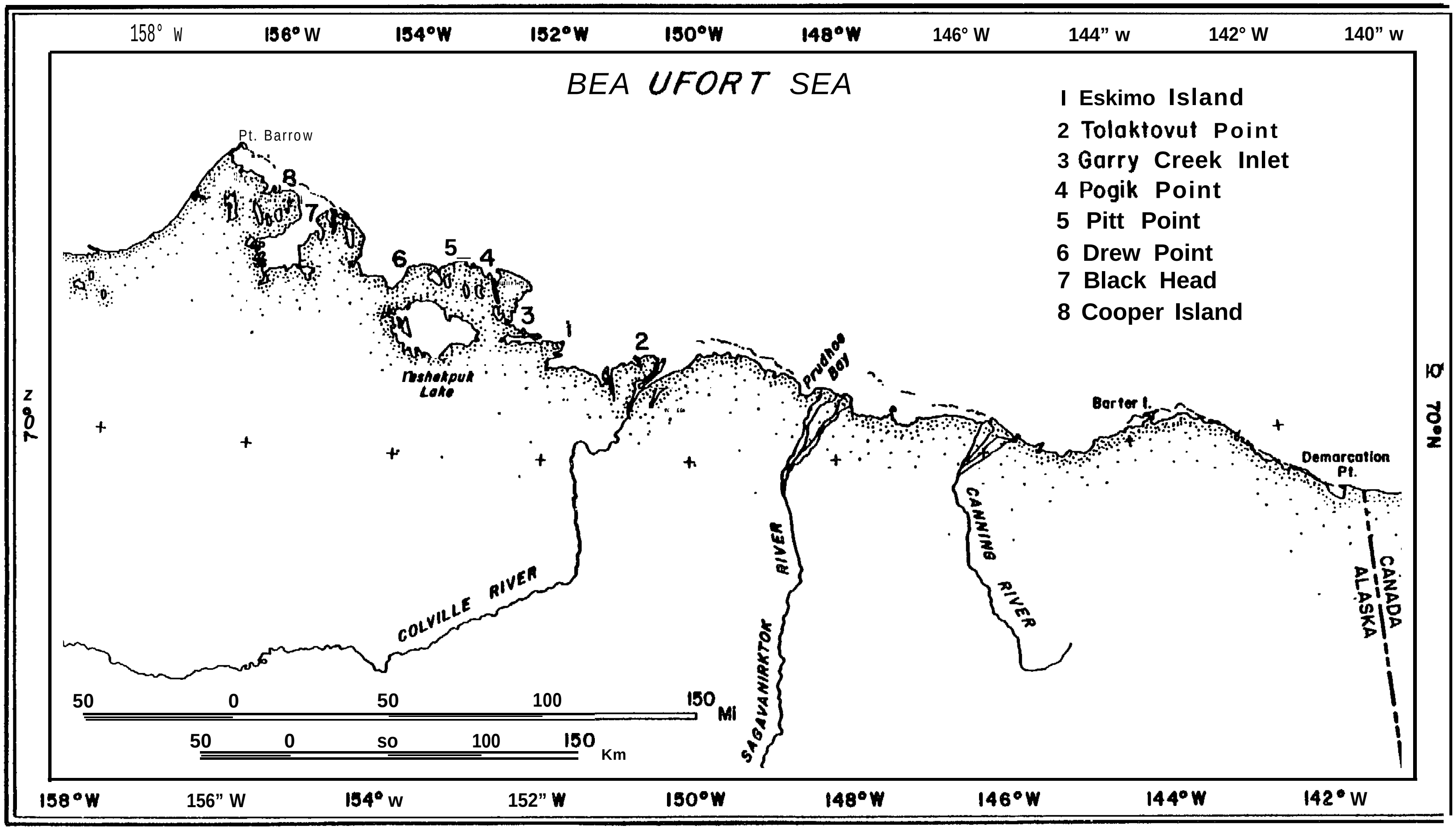

Figure 2. Sampling site locations for the 1982 western Beaufort Sea fish survey.

Site No.	USGS Name	Description
1.	Eskimo Island	70°34'N, 151°55'W. A vegetated island with a sandy shoreline. Net was set from the southwestern shore of the most easterly island.
2.	Tolaktovut Point	70°28'N, 150°54'W. A vegetated point with sandy/muddy substrate and numerous submerged peat mats. Net was set on the western side of the point.
3.	Garry Creek Inlet	70°38'N, 152°27'W. Net was set along the north shore of the inlet where it empties into Harrison Bay. The substrate was muddy and there was much water-borne peat.
4.	Pogik Point	70°54'N, 152°53'W. Net was set on the south side of the island. Substrate was sand and gravel. The initial set was on the north side and was snagged by ice.
5.	Pitt Point	70°55'N, 153°10'W. Net was set north from the beach at a location approximately 2 km west of Pitt Point.

6.	Drew Point	70°53'N, 153°56'W. Net was set from the point extending westward. The substrate was muddy and there was much water-borne peat.
7.	Black Head	71°04'N, 155°16'W. The net was extended westerly and set slightly offshore to avoid shallow areas with water-borne peat.
8.	Cooper Island	71°14'N, 155°42'W. The net was set on the lagoon side of a spit which extends south from Cooper Island. The substrate was sand and gravel.

Fish collections from each sampling station were categorized and enumerated by species and each fish measured (fork length) to the nearest 5 mm. The sex and state of maturity of pink salmon was also recorded. Salmon were considered ripe if sex products were readily extrudable. On two occasions, dissection was necessary to distinguish Bering cisco from the more abundant Arctic cisco.

Temperature, salinity and time of day was recorded when each net was set and again when they were pulled. Temperature was measured to the nearest 0.1°C with a hand-held calibrated thermometer and salinity was measured with an AO Model 10419 optical refractometer calibrated against a distilled water standard. Temperature and salinity data at each net location is presented in Appendix I.

RESULTS

During the 1982 western Beaufort Sea survey, a total of 1,201 fishes comprised of 13 species were caught (Table 1). Eight species including Arctic char, pink salmon, rainbow smelt and the Coregonid whitefish were anadromous; four species, capelin, fourhorn sculpin, Arctic flounder and saffron cod were marine; and one species, round whitefish, was freshwater. Anadromous fish catches were lead by least cisco (41.6%) following by Arctic cisco (24.9%). Marine species were dominated by fourhorn sculpin (94.2%) and followed by Arctic flounder (4.5%)

The total catch at Eskimo Island was of course higher since that net was run every day. Seven hundred forty-seven fish were caught during 9 netting efforts for an average catch of 83 fish per effort.

Species Accounts

The following accounts for the 13 species captured during this survey are taken from various sources in the scientific literature. These accounts provide a general overview of life history trends and distribution. The findings of this survey are discussed relative to these accounts. Emphasis is placed upon the more high profile nearshore anadromous fishes (Arctic cisco, least cisco, broad whitefish, humpback whitefish, Arctic char and pink salmon).

Arctic Cisco (*Coregonus autumnalis*)

The Arctic cisco ranks as one of the most important and abundant anadromous fishes of the nearshore Alaskan Beaufort Sea. This species is targeted by subsistence fisheries along the northern coastline of Alaska from Demarcation Point to Point Barrow. This species also helps support small commercial fisheries in the Colville Delta and near Point Barrow (Bendock 1979a).

Table 1. Total catch, percentages of total catch and percentages of group (anadromous, freshwater or marine) for each species at each station. Stations are numbered as follows: l-Eskimo Island, 2-Tolaktovut Point, 3-Garry Creek Inlet, 4-Pogik Point, 5-Pitt Point, 6-Drew Point, 7-Black Head, 8-Cooper Island.

Species	Stations 1	2	3	4	5	6	7	8	Total	% of Total		% of Group
Arctic cisco	152		1	10	33	4		5	205	17.1		24.9
Least cisco	198		1	2	80	6	52	3	342	28.5		41.6
Arctic char	12	1			12			4	29	2.4		3.5
Broad whitefish	12	15	6		2		2		37	3.1	Anadromous	4.5
Humpback whitefish	36	1			2		26		65	5.4		7.9
Bering cisco					1	1			2	0.2		0.2
Pink salmon	10			1	18	5	16		50	4.2		6.1
Rainbow smelt	90		2						92	7.7		11.2
Round whitefish	1	1							2	0.2	Freshwater	100.0
Capelin								4	4	0.3		1.1
Fourhorn sculpin	222	40	5	2	11	11	41	23	355	29.6	Marine	94.2
Arctic flounder	15	2							17	1.4		4.5
Saffron cod	1								1	0.1		0.3
Total	749	60	15	15	159	27	137	39	1,201			

The range of this species includes northern Europe and Siberia and the western Arctic coast of North America. In the latter region the range extends from Bathurst Inlet, Northwest Territories, Canada, west to Point Barrow, Alaska (Scott and Crossman 1973, Morrow 1980).

The Arctic cisco is truly anadromous in behavior. Overwintering occurs in the brackish-water delta regions of the Colville (Alaska) and Mackenzie (Canada) rivers and a summer feeding dispersal from the deltas occurs at the onset of breakup of fast ice along the nearshore Beaufort Sea (Gallaway et al, in press). Spawning and early life histories have been reasonably well documented in the Mackenzie River system (Wynne-Edwards 1952, Hatfield et al. 1972, Stein et al. 1973, McLeod et al. 1979, O'Neal et al. 1981, Taylor et al. 1982). Upstream spawning migration occurs from late June through October with timing depending upon the distance up the Mackenzie the fish must move. The Liard River (1600 km upstream of the delta) is the furthest upstream tributary of the Mackenzie system known to support spawning populations cf Arctic cisco and the peak run occurs here in September. Eggs are laid in the fall and a post-spawning downstream migration occurs with large numbers of spawned-out fish present in the Mackenzie 'Delta by early October. Eggs hatch the following spring and young of the year move downstream during breakup to spend the summer in the delta and nearshore regions.

It is notable that numerous fisheries investigations conducted on the Colville River system have failed to provide conclusive documentation of spawning populations of Arctic cisco in the system (Bendock 1979a, McElderry and Craig 1981, Craig and Griffiths 1981). Gallaway et al. (in press) summarized "these studies indicate that Arctic cisco likely do not penetrate the Colville River beyond Umiat (about 175 km upstream), are abundant only as far upstream as the Itkillik River (about 17.5 km) and few, if any, of these fish are in spawning condition." Also, the fall/winter commercial fishery conducted in the Colville Delta has failed to catch Arctic cisco in spawning condition or post-spawning condition although these fish would be expected to be vulnerable to the fishery if spawning occurred in the Colville River.

Gallaway contends that Arctic cisco in Alaska are representatives of a Canadian stock from the Mackenzie system. If this is the case, it appears that a portion of the young Arctic cisco dispersing westward from the Mackenzie system are picked up and distributed by the prevailing east to west longshore currents along the Alaskan Beaufort Sea coast. Following the summer feeding dispersal, overwintering in Alaska occurs in the deltaic regions of the Colville River and possibly other large rivers of the North Slope. The summer after attaining sexual maturity, males at seven years and females at eight years (Craig and Haldorson 1981), these fish apparently leave the Alaskan coastline, returning to natal waters of the Mackenzie system to spawn.

Invertebrates are the principal food of Arctic cisco. In Simpson Lagoon mysids (Mysis litoralis and M. relicts) accounted for 70-87% of their summer diet, whereas a single species of amphipod (Pontoporeia affinis) was found to be the major prey eaten in winter (Craig and Haldorson 1981). Additional groups important to the diet of Arctic cisco include copepods, larval fish, chironomid larvae and polychaetes.

Arctic cisco were the second most abundant anadromous fish in gillnet catches of the nearshore western Beaufort Sea. A total of 205 were captured, representing 17.1% of the overall catch and 24.9% of the anadromous fish caught. Length frequency data are presented in Figure 3.

Least Cisco (Coregonus sardinella)

The least cisco is one of the most widely distributed fishes of Alaska. It is present in most streams and lakes north of the Alaska Range and can be found in brackish, nearshore waters from Bristol Bay to the Arctic coast. On the north-slope numerous streams west of and including the Colville River support anadromous and resident populations of least cisco. However, they are not found in drainages between the Colville and Mackenzie rivers although the Mackenzie drainage supports a substantial population. Hablett (1979) found that after ninespine sticklebacks, least cisco were the most widespread and numerous fish

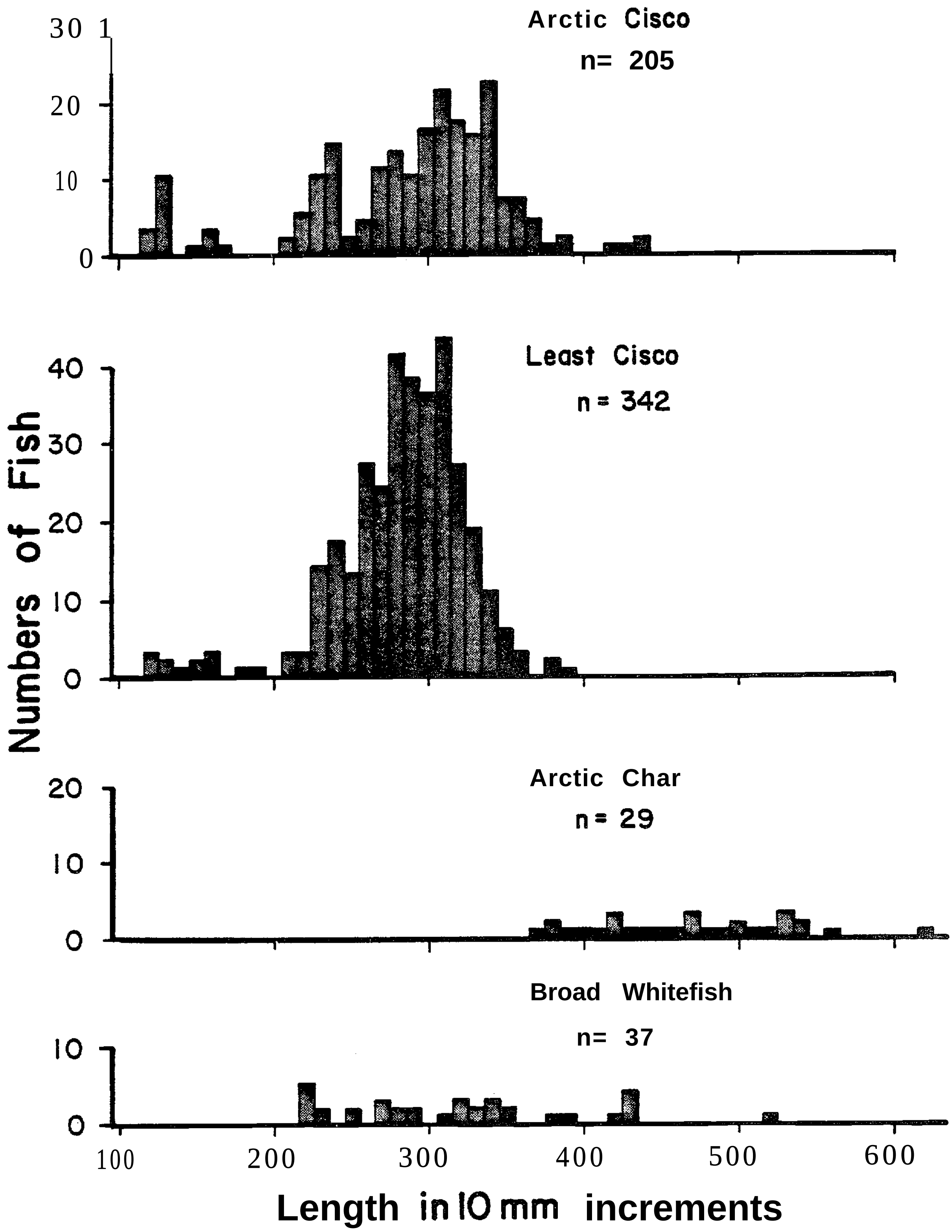

Figure 3. Length-frequency histograms for Arctic cisco, least cisco, Arctic char and broad whitefish.

encountered during stream and lake surveys of the NPR-A (within an approximate 300 km radius of Pt. Barrow). Least cisco were also the most abundant fish caught during fall gillnet sampling of the lower Colville drainage (McElderry and Craig 1981).

Overwintering occurs in brackish waters associated with river deltas. A wide salinity tolerance has been noted in overwintering least cisco which have been collected in salinities from 18 to 32 o/oo in the Colville Delta to as low as 0.2 o/oo in nearshore coastal waters off the Mackenzie River (Craig and Haldorson 1981). As breakup commences anadromous least cisco move into the nearshore zone of the Beaufort coast to feed. However, this summer dispersal is not as extensive as that observed for Arctic char or Arctic cisco.

Spawning presumably occurs in September or October in the Colville drainage. Least cisco in or nearing spawning condition were collected in the lower 60 km of the Colville downstream of Ocean Point in the delta and in several coastal lakes during late August and September (McElderry and Craig 1981). Eggs are released and fertilized over gravel and sand substrate where they remain through the winter. Hatching begins in spring and fry move downstream to deeper, slower water.

Age at maturity ranges from 6 to 7 years for males and 7 to 10 years for females. Few individuals live more than 13 to 14 years, however, fish to 18 years were captured in Simpson Lagoon during 1977 (Craig and Haldorson 1981), and specimens to 26 years are reported from Victoria Island, Northwest Territories (Scott and Crossman 1973).

During the summer months fish collected in Simpson Lagoon fed heavily on mysids (66 to 69% of their diet), however, during the winter months amphipods became the major prey group obtained in the Colville Delta (Craig and Haldorson 1981). Other food groups found to be of importance include copepods, larval fish and insects.

On the North Slope least cisco are captured in domestic fisheries aimed primarily at Arctic cisco. The more oily flesh of the latter makes it more sought after as food while least cisco is used as dog food . A fall and winter commercial fishery also exists in the Colville Delta in which approximately 30 to 70% of the catch is least cisco.

Least cisco were the most abundant anadromous species encountered during 1982 sampling efforts in the western Beaufort Sea. A total of 342 least cisco were caught in gillnets representing 28.5% of the overall catch and 41.6% of the anadromous species captured., The size distribution of least cisco are presented in Figure 3.

Arctic Char (*Salvelinus alpinus*)

The Arctic char is widely distributed throughout arctic waters of the northern hemisphere. It is present in rivers and coastal regions of northern Europe and Asia, the British Isles, Greenland and North America. This species exhibits two life history patterns: an anadromous pattern in which a seaward migration is undertaken and a non-anadromous pattern in which the fish remain and mature in streams or rivers (a second non-anadromous form is also recognized which is represented by isolated, landlocked populations in several Brooks Range alpine lakes). Although anadromous char are found along the entire North Slope coast they are generally associated with fast-flowing 'Mountain Streams' typical of many of the drainages of the eastern Beaufort Sea (Craig and McCart 1975).

Following a summer feeding dispersal in salt water, char return to streams in August and September to spawn and/or overwinter. The juvenile or immature fish entering streams to overwinter are preceded by mature adults returning to spawn. The latter specifically seek their natal streams at this time while immatures may overwinter in streams other than those of their origin.

Sexual maturity is first reached by males and females at 7 and 6 years, respectively, in anadromous char from the Anaktuvuk River (Bendock 1981). Spawning takes place from late August through November with most activity occurring in September and October. Redds are excavated in gravel substrates in regions of spring sources (Bain 1974, Bendock 1981 and Yoshihara 1973). The eggs are buried and remain in the gravel about 4 months until hatching. After hatching, the fry remain concealed in the gravel until the yolk sac is absorbed, emerging in May or June (Bain 1974 and Yoshihara 1973). The young remain in their natal stream for 2 to 5 years prior to their first migration to salt water. It appears that not all individuals within a population go to sea and that a greater percentage of females than males are anadromous (Bain 1974).

Young Arctic char feed primarily on aquatic insects and crustaceans during their residence in rivers (McPhail and Lindsey 1970, Morrow 1980 and Bain 1974). From Arctic char collected in salt and brackish water of the Beaufort Sea, mysids and amphipods were found to be the major prey species (Craig and Haldorson 1981 and Yoshihara 1973).

A total of 29 Arctic char were captured during the 1982 western Beaufort sampling, representing only 2.4% of the overall catch and only 3.5% of the anadromous fish catch. The size distribution of char is represented in Figure 3. No small juveniles were present in the collection which consisted of fish from 370 to 620 mm in length.

Broad Whitefish (Coregonus nasus)

The broad whitefish is distributed in the fresh and brackish waters of northern Siberia and the western arctic coast of North America. In the latter region, its range extends from the Kuskokwim River, Alaska, north to the Beaufort Sea and east to the Perry River, Northwest Territories (Morrow 1980, Scott and Crossman 1973). Although anadromous this species seldom ventures far from the brackish waters of estuarine areas.

Broad whitefish in the Beaufort Sea were found to be slow growing, late maturing and long lived (Craig and Haldorson 1981 and Bendock 1979a). From specimens collected in Simpson Lagoon maturity was found to be reached at an age of 9 to 14 years and individuals to 21 and 22 years old were collected.

Broad whitefish enter the Beaufort Sea during spring breakup to feed in the river deltas, shallow bays and lagoons of the nearshore regions through the summer (Bendock 1979a and Alt and Kogl 1973). In late August mature adults return to the Sagavanirktok River to spawn in deep pools in the delta area (Bendock 1979a). In the Colville River a large spawning migration occurs in the Umiat area (about 175 km upstream) in mid-August and spawning was observed farther upstream during September (Hablett 1979). Eggs are deposited in gravel where they remain until hatching the following spring. Hablett (1979) reports young-of-the-year and immature broad whitefish make extensive use of the overflow channels and oxbows connected to the Colville River. However, it appears that some of the fry migrate downstream, as ages 0, 1 and 2 were reported in fyke net catches in the brackish water of the Sagavanirktok Delta (Gallaway and Britch 1983).

Major food groups of the broad whitefish include chironomid larvae, amphipods, snails and bivalve mollusks (Bendock 1979a,b and 1979 and Morrow 1980).

The broad whitefish is considered one of the finer tasting of arctic fish and is the target species of a summer subsistence fishery conducted in the Colville River. In the lower reaches of this river broad whitefish were the fourth most abundant fish captured during fall gillnet sampling between 23 September and 15 November 1972 (Kogl and Schell 1974). This species contributes significantly to other subsistence fisheries along the Western Beaufort for example in subsistence catches observed near Atqasuk on the Meade River August 11, 1981 broad whitefish were found to be the most abundant fish taken (Craig and Schmidt 1982) .

During the 1982 sampling, 37 broad whtiefish were caught accounting for 3.1% of the overall catch and 4.5% of the anadromous fish caught. The length frequency data is presented in Figure 3.

Humpback Whitefish (Coregonus pidschian)

The humpback whitefish falls within the 'Coregonus clupeaformis complex' from which as many as three species are recognized. However, this is a source of considerable controversy as almost the only means of distinguishing them is by the modal number of gill rakers in large samples. Members of this complex are widespread throughout the northern regions of North America, being found in western Alaska from Bristol Bay north and east across most of Canada to New Brunswick and Labrador and south to the Great Lakes. Along the western Beaufort Sea the humpback whitefish is found in coastal lakes and all the major drainages east of Barrow to the Sagavanirktok River (Bendock 1979a and Hablett 1979). Bendock (1979a) considers the Colville River as the largest producer of humpback whitefish on the North Slope.

Life histories are not well understood for the anadromous Beaufort Sea populations presumably because it is not found in great numbers nor does it contribute appreciably to domestic fisheries in this region and has consequently not received much attention.

During the openwater season, humpback whitefish probably do not disperse far from the brackish waters of stream estuaries. Relatively few were captured in Simpson Lagoon (Craig and Haldorson 1981) and Bendock (1979a) found them sparsely distributed between the Colville and Sagavanirktok rivers with increasing numbers nearer the Colville.

An upstream migration has been observed at Umiat on the Colville River from mid-August to early September and spawning occurs from September to October from the delta to as far as 200 km upstream (Hablett 1979, Bendock 1979b, Kogl and Schell 1974). Following spawning a movement back into the lower reaches of the Colville was observed by Kogl and Schell (1974). Eggs are believed to hatch in late winter or early spring.

Age at maturity ranges from 4 to 6 years in Alaskan populations (Morrow 1980) and spawning most likely occurs every other year (McPhail and Lindsey 1970). In lakes of northern Canada fish as old as 28 years have been captured, however, the anadromous fish of the Beaufort Sea populations appear to be shorter lived with maximum ages ranging from 11 to 13 years (Kogl and Schell 1974, Hablett 1979 and Bendock 1979a).

Food habits of the humpback whitefish indicate bottom feeding. Major prey items of young fish are zooplankton while those of adults include bivalve mollusks, snails, chironomids and amphipods (Kogl and

Schell 1974, Alt 1979 and Morrow 1980). During spawning humpback whitefish were found to consume large quantities of their own eggs but amphipods comprised the major food item of overwintering fish in the lower Colville during October (Kogl and Schell 1974).

The humpback whitefish contributes to local subsistence fisheries although to a lesser degree than other anadromous fishes. Kogl and Schell (1974) found them to be the most abundant fish caught during sampling in the Colville Delta between 24 September and 15 November. However, Alt and Kogl (1973) state that they comprise only 10% of the summer subsistence catch and only 1% of the winter catch in the Colville River.

Humpback whitefish were the fifth most abundant fish captured during sampling efforts with a total of 65 representing 5.4% of the entire catch and 7.9% of the anadromous fish catch. Length frequency data is presented in Figure 4.

Bering Cisco (*Coregonus laurettae*)

The Bering cisco is found along western Alaska from Bristol Bay north and east to the Colville Delta. The distributions of Bering and Arctic cisco overlap between Pt. Barrow and the Colville River causing some confusion regarding identity.

The Bering cisco is very similar in appearance to the Arctic cisco from which it is most easily distinguished by fewer gill rakers on the lower portion of the first gill arch. The Bering cisco has 18-25 gill rakers here, whereas the Arctic cisco has 26-31 (Morrow 1980). Craig and Haldorson (1981) also noted that the Bering cisco appear somewhat stouter or thicker than Arctic cisco of the same length.

Little is known of the biology of the Bering cisco and what is known is chiefly-from the Yukon and Kuskokwim populations. Spawning migration commences in spring however actual spawning presumably takes place in fall. Spawning behavior and choice of spawning grounds is unknown, although it is thought to take place in clearwater tributaries

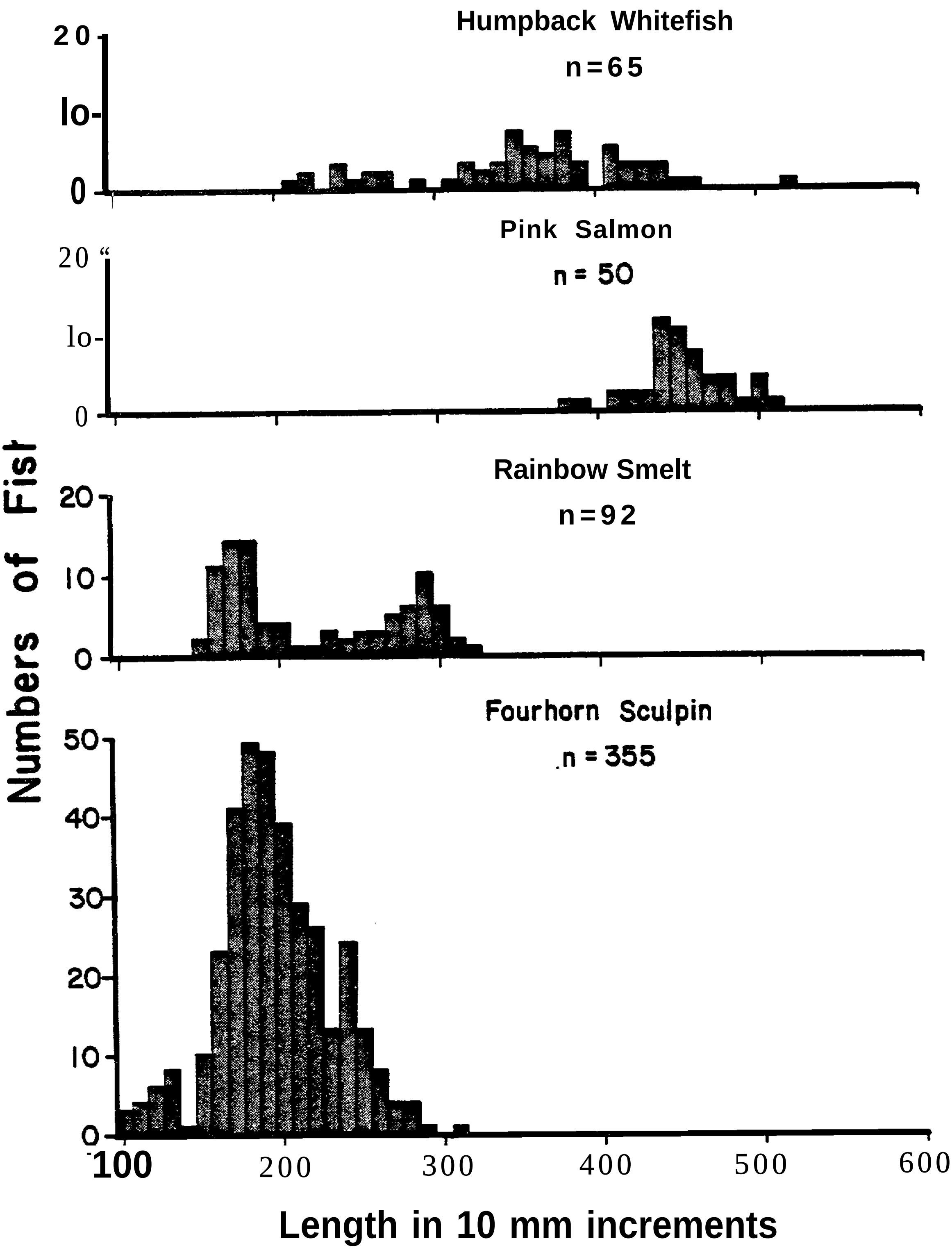

Figure 4. Length-frequency histograms for humpback whitefish, pink salmon, rainbow smelt and fourhorn sculpin.

of the rivers. Downstream migrations follow spawning and overwintering occurs in brackish or salt water in the river deltas.

Bering cisco feed primarily on crustaceans (amphipods) although larval fish (cottids) have also been reported in stomach contents (McPhail and Lindsey 1970 and Alt 1973).

Only 2 Bering cisco, one 370 mm and one 390 mm in length, were collected during the 1982 sampling efforts.

Pink Salmon (*Oncorhynchus gorbuscha*)

Pink salmon are found in most larger drainages of northwest Asia and North American north of 35° N latitude and which drain into the North Pacific and Arctic oceans. In North America the range extends from the Sacramento River, California, north to the arctic coast of " Alaska and east to the Mackenzie River, Northwest Territories (Scott and, Crossman 1973). Adult pink salmon are present in late summer along the entire Beaufort coastline and have been reported to enter the Meade, Chipp and Colville rivers (Hablett 1979, Bendock 1979a, Craig and Haldorson 1981).

By mid- to late-summer adult pre-spawners begin to appear along the coastline moving in an easterly direction. Adult pink salmon were captured in the Chipp river during the first week of August, 1977 (Hablett 1979) and they enter the Colville River during mid-August (Bendock 1979a, Craig and Haldorson 1981, Hablett 1979). Spawning occurs in the mainstream of the Colville River and possibly in the lower reaches of tributaries such as the Itkillik, Chandler and Anaktuvuk rivers (Bendock 1979a). Spawning probably occurs in North Slope drainages other than those listed above, however, the current knowledge of the region west of the Colville River is based on relatively few sampling efforts.' Also, pink salmon do not exhibit as strong a homing instinct as other Pacific salmon and have been found spawning in streams up to 640 km from their natal streams (Morrow 1980).

Eggs are laid in redds dug in gravel. The eggs hatch during the winter however the alevins remain in the gravel, until the yolk sac is absorbed, emerging later in spring. After emerging from the gravel the fry begin moving downstream. They remain in the estuary for up to a month prior to moving offshore. Little is known of the movements undertaken during the 18 months the salmon spend at sea. It is likely the North Slope populations move westerly towards the Chukchi Sea and upon maturing at the age of 2 years the salmon then return to their natal streams to spawn in the fall.

Young-of-the-year probably do not feed significantly during the short period spent in natal streams but feed on copepods and other zooplankton in the estuary. As the fish grow, larger prey species become important including amphipods, euphausiids and fishes (Morrow 1980 and Scott and Crossman 1973).

The pink salmon is caught in subsistence fisheries along the Beaufort coastline and in the Colville River. Because of large year to year fluctuations in numbers of pink salmon (Bendock 1979) its importance in domestic fisheries varies.

A total of 50 pink salmon were caught which represented 4.2% of the overall catch and 6.1% of the anadromous fish catch. Length frequency data is presented in Figure 4. Except for 1 ripe male, the state of sexual maturity of the entire catch prior to 30 July was found to be green, however, from 30 July to 3 August, 18 of 24 salmon caught were determined to be ripe (see Appendix 11).

Rainbow Smelt (Osmerus mordax)

The rainbow smelt is circumpolar in distribution ranging in the west Pacific Ocean from Korea and northern Japan north to the Arctic Ocean and west across northern Siberia and Europe. In North American it is found along the Eastern Pacific from Vancouver Island north to the Arctic Ocean and east to Cape Bathurst in the Canadian arctic and from Labrador to Virginia, including the Great Lakes watershed, along the Atlantic Ocean.

This anadromous smelt is a spring spawner. Through the winter rainbow smelt were found concentrated off the delta of the Colville

River until the first influence of meltwater at breakup. It was presumed that these fish migrated into the river at that time to spawn (Craig and Haldorson 1981). Typically rainbow smelt do not travel far upstream to spawn and have been observed spawning in brackish water near the mouths of streams (Morrow 1980). The minute young soon hatch and are carried downstream to the estuary. As they continue to grow, the young fish are found ranging farther into more saline waters, however, Morrow (1980) indicates that they do not range far from their natal streams.

Rainbow smelt reach maturity at 5 to 7 years and individuals to 15 years have been caught in Simpson Lagoon (Craig and Haldorson 1981).

Food of the young rainbow smelt include copepods, cladocerans and other zooplankton while adults feed on mysids, amphipods and small fish such as Arctic cod (Morrow 1980 and Craig and Haldorson 1981).

Rainbow smelt were the fourth most abundant fish in the western Beaufort collections with a total of 92 representing.7.7% of the overall catch and 11.2% of the anadromous fish catch. The size distribution of rainbow smelt depicts a bimodal curve with peaks at lengths of 180 mm and 290 mm (Figure 4).

Round Whitefish (Prosopium cylindraceum)

The round whitefish is an accidental visitor of the nearshore regions of the Beaufort Sea. This freshwater species is widely distributed across northeastern Asia and North America. The round whitefish spawns in fall. Northern populations tend to be slower-growing, longer-lived and later maturing than those from the southern parts of its range (Morrow 1980).

During periods of high runoff and resulting low nearshore salinities, the round whitefish is occasionally caught in the nearshore coastal zone (Bendock 1979a and Craig and Haldorson 1981).

Food of the round whitefish include snails, bivalves, aquatic insects and phytoplankton (Hablett 1979, Morrow 1980).

Round whitefish was the only freshwater species represented in the 1982 western Beaufort collections. Only 2 were captured during the sampling efforts with lengths of 150 and 270 mm.

Capelin (*Mallotus villosus*)

The capelin is a marine species which is relatively infrequently encountered along the Beaufort Sea coast. This fish is found in the North Pacific, North Atlantic and Arctic Oceans.

Capelin enter shallow waters to spawn during the summer. Near Pt. Barrow spawning occurred in late July and August during which time they were captured in dip nets by local residents for food. In Prudhoe Bay spawning occurred in mid-August (Bendock 1979a). Fish enter the surf zone along gravel beaches to lay adhesive eggs which stick to the gravels. Eggs hatch in 2 to 3 weeks.

Movements of capelin within the Beaufort Sea are poorly understood. Age at maturity may be 1 year and capelin do live to be 3 or more years (Hart 1973). Euphausiids and copepods have been observed in the food of specimens collected in British Columbia.

Only four capelin were collected during the present study and all of these were obtained at Cooper Island. Lengths ranged from 130 to 140 mm.

Fourhorn Sculpin (*Myoxocephalus quadricornis*)

The fourhorn sculpin is a marine species abundant along the Arctic coast from Norton Sound, Alaska, north and east across northern Canada to Greenland. During the openwater season on the Beaufort Sea coast these sculpin move into the shallow, nearshore brackish waters to feed, returning to deeper waters offshore of the barrier islands to overwinter and/or spawn.

Spawning occurs sometime between late November and late February in the vicinity of Simpson Lagoon. Females lay the entire batch of eggs in a single clump which is guarded by the male until hatching in spring.

In Simpson Lagoon populations maturity was reached 1 to 3 years earlier than in populations farther east from Nunaluk and Katovik Lagoons. Males reached maturity as early as 2 years and all were mature by 4 years while female sculpins matured between the ages of 4-6.

During the summer months, the diet of sculpins collected in Simpson Lagoon consisted almost entirely of crustaceans. Amphipods represented 81%, mysids 10% and isopods 6% of the total food consumed. In the winter isopods were the major prey species (60-78%) followed by amphipods 5-31% and fish eggs 5-9% (Craig and Haldorson 1981). Isopods and amphipods, were indicated as important prey species at other coastal locations as well.

Fourhorn sculpin were the most abundant fish in the 1982 sampling efforts along the western Beaufort Sea. A total of 355 fourhorn sculpin represented 29.6% of the overall catch and 94.2% of the saltwater fish. Length frequency data is presented in Figure 4.

Arctic Flounder (*Liopsetta glacialis*)

The Arctic flounder is distributed in coastal waters of the Bering and Chukchi seas north into the Arctic Ocean from Queen Maude Gulf in Arctic Canada west along the North American and Siberian coastline to the White Sea and Barents Sea (Morrow 1980).

Winter spawning occurs from January to March at which time the flounders move into shallow waters at depths of 5 to 10 m. Maturity is reached by age 4 or 5 years with some as early as 2 years (Morrow 1980).

Food items of Arctic flounder collected in Simpson Lagoon and Prudhoe Bay include amphipods, mysid, and isopods (Bendock 1979a and Criag and Haldorson 1981), and other prey include small mollusks and fishes (Morrow 1980).

This marine" species is associated with shallow brackish coastal waters and apparently exhibits an offshore movement in the fall and an onshore movement in the spring (Morrow 1980).

Only 17 Arctic flounder were caught in the western Beaufort sampling effort, however, following fourhorn sculpin it is the second most abundant saltwater species, representing 4.5% of this group. Lengths ranged from 150 to 320 mm with most (82.4%) 200 mm or less.

Saffron Cod (*Eleginus gracilis*)

The saffron cod is present along the entire Beaufort Sea coast although it is not found in large numbers here. Spawning occurs from December to February at which time fish move into shallower nearshore water. The young hatch in spring and are planktonic for the first few months of their lives (Morrow 1980). Age at maturity is not known for Beaufort Sea populations but has been reported as 2 to 3 years in Siberian waters (Morrow 1980).

Saffron cod migrations are somewhat limited except for an onshore movement in fall and winter prior to spawning and the subsequent offshore movement to deeper summer feeding areas. It occasionally is found in rivers though seldom farther upstream than the influence of salt water.

Food items include fish, mysids, amphipods and polychaete worms (Morrow 1980 and Craig and Haldorson 1981).

Only 1 saffron cod 220 mm in length was collected during the 1982 sampling efforts.

Benchmark Location Catches (Eskimo Island)

Catches for each species at the Eskimo Island location are listed in Appendix III and graphically presented in Figures 5, 6 and 7. Catches assumed a great deal of variation throughout the survey period, however, several peaks in the CPUE values are apparent. Catches of some anadromous fishes and fourhorn sculpin were high during the early days of the survey on 25 and 26 July and again between 31 July and 3 August. Arctic cisco were the most abundant fish during the first days of the survey and least cisco and fourhorn sculpin dominated later in the survey. Humpback whitefish showed a relatively high abundance initially, as did Arctic char, however, abundance of these two species

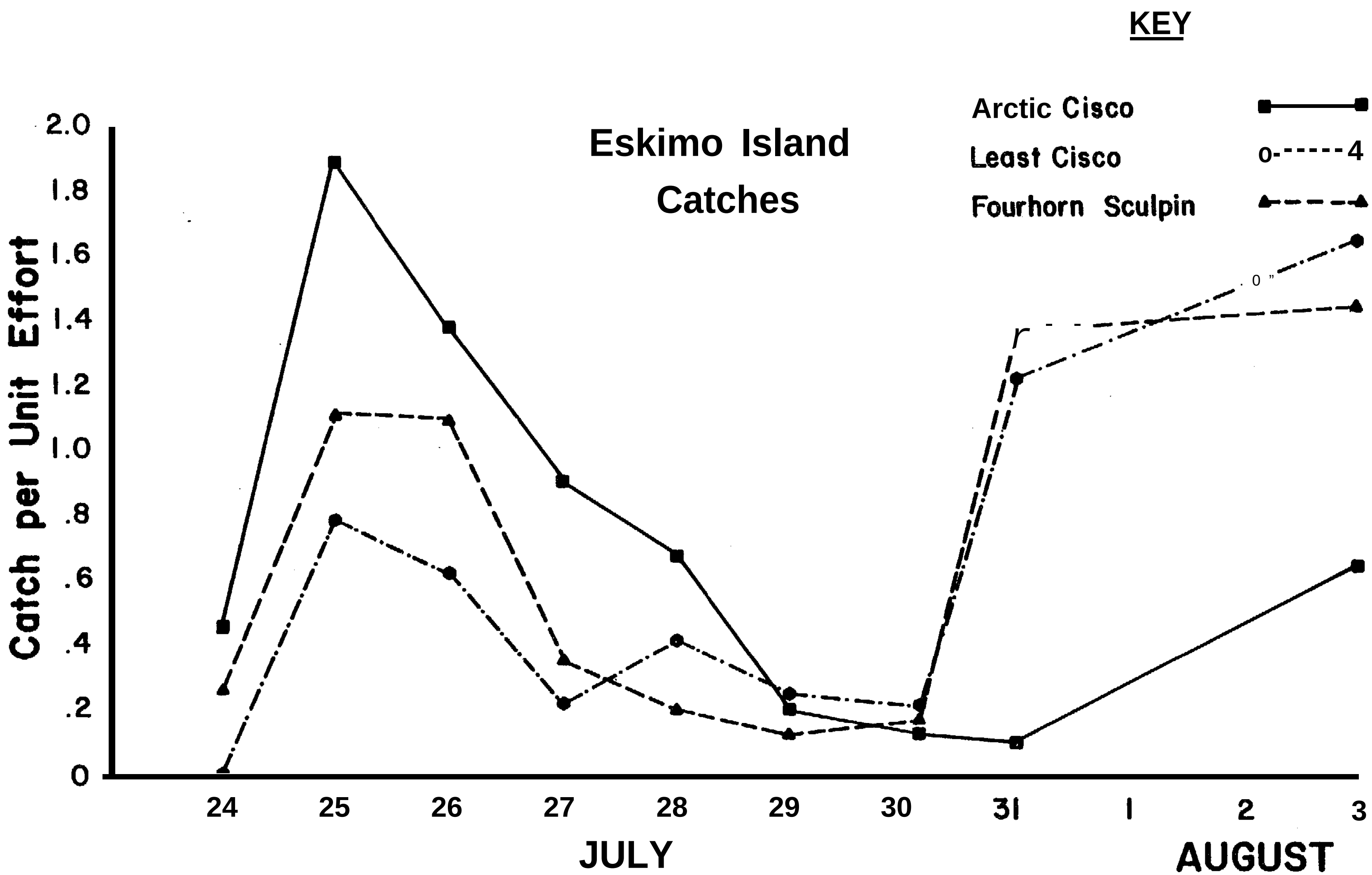

Figure 5. CPUE Values for Arctic cisco, least cisco and fourhorn sculpin at the Eskimo Island location.

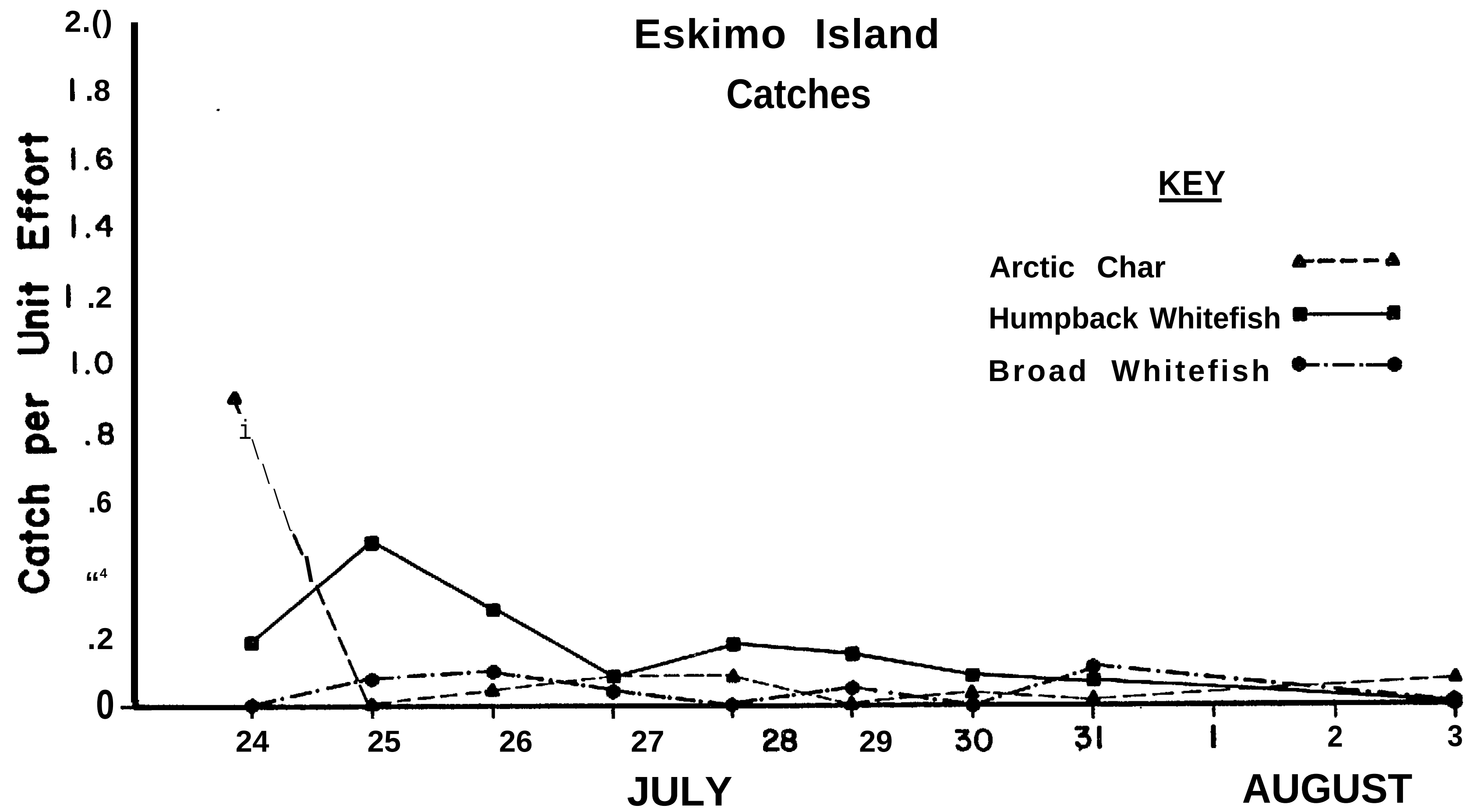

Figure 6. CPUE Values for Arctic char, humpback whitefish and broad whitefish at the Eskimo Island location.

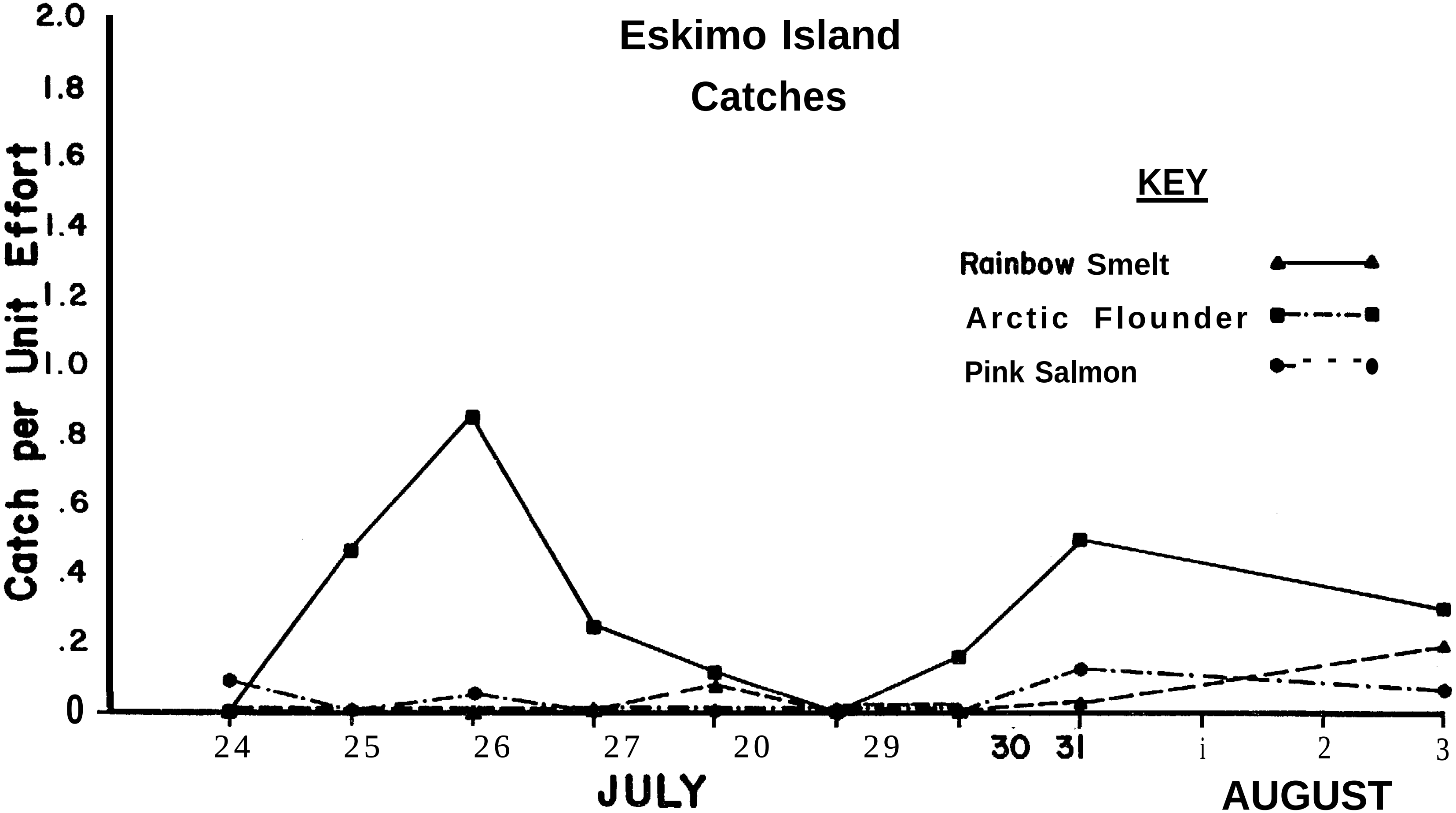

Figure 7. CPUE values for rainbow smelt, Arctic founder and pink salmon at the Eskimo Island location.

declined later in the survey. Catches of broad whitefish remained low during the entire survey. Rainbow smelt exhibited two peaks in abundances one early in the survey and one later, that coincide with those of Arctic cisco and fourhorn sculpin and to some degree with that of least cisco. Abundance of pink salmon remained low throughout the survey. This species first appeared at the Eskimo Island location on 28 July, one day after it was documented at Pogik Point to the west (Appendix II) . None of the salmon caught at that time were ripe, however, maturation seems to begin during this time frame since several of the later catches contained ripe salmon.

Figure 8 shows the catches at the Eskimo island location pooled into anadromous and marine species and compared using CPUE values. The trend for anadromous fishes was similar to that for Arctic and least cisco (Figure 5) with peak catches at the beginning and end of the survey period and truncated catches during mid-survey. The pooled CPUE values for marine fishes showed a trend nearly identical to that of fourhorn sculpin. This result was not wholly unexpected since this species comprised 94.2% of the marine catch.

Temperature and salinity measurements taken at the Eskimo Island location showed trends similar to those of other studies (Craig and Haldorson 1981; Griffiths and Gallaway 1982; Gallaway and Britch 1983). Mean temperatures were generally higher early in the survey with the highest, 13.4°C, occurring on 25 July, thereafter steadily decreasing (Figure 9). Salinities steadily increased due primarily to the general lack of freshwater influence from melting sea ice and freshets.

To test whether CPUE value for each species are influenced by temperature or salinity, a least squares linear regression was performed. Results were tabulated for all species except saffron cod, capelin, round whitefish and Bering cisco. These species were omitted due to their low numbers. Linear regressions, y intercepts and correlation coefficients are given in Appendix IV. The CPUE values for two species, Arctic cisco and humpback whitefish, were significantly correlated ($p < 0.05$ and $p < 0.01$, respectively) with temperature; and CPUE values for least cisco and pink salmon were significantly

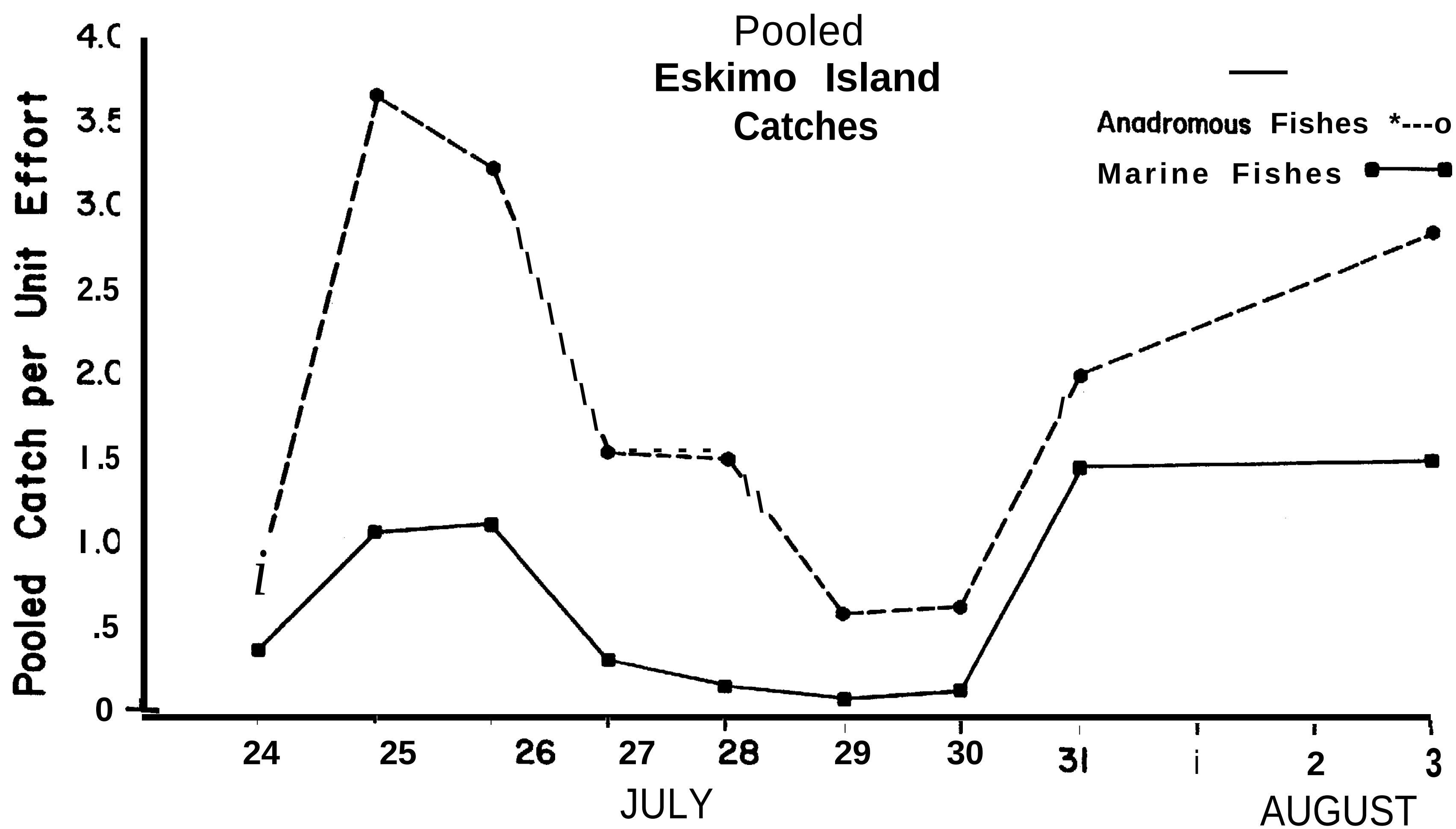

Figure 8. Pooled CPUE values for anadromous and marine fishes at the Eskimo Island location.

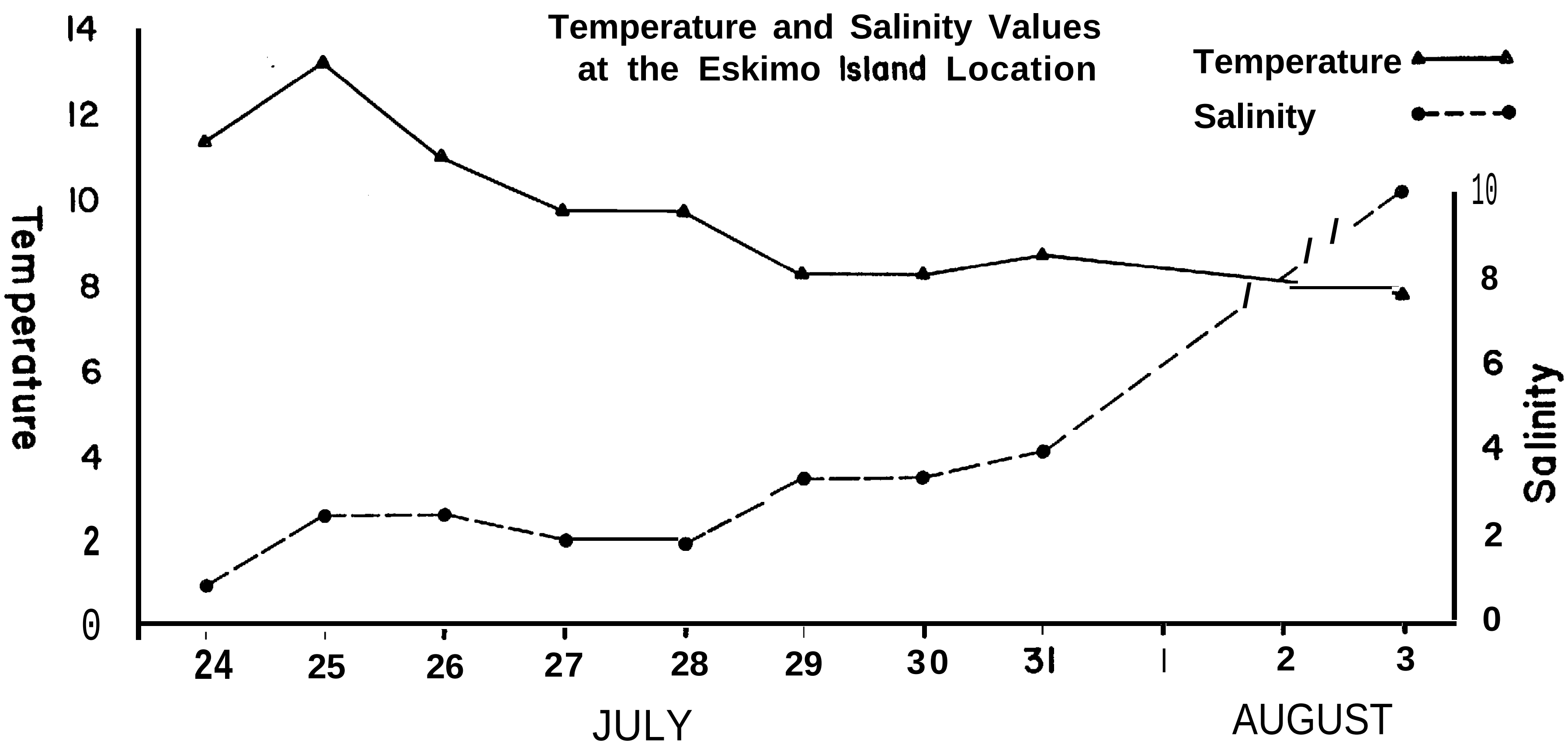

Figure 9. Mean temperature and salinity values taken at the Eskimo Island location.

correlated ($p < 0.01$) with salinity. The remaining species show no significant correlation with either temperature or salinity.

Single Survey Location Catches

Catches at the single survey locations, Tolaktovut Point, Garry Creek inlet, Pogik Point, Pitt Point, Drew Point, Black Head and Cooper Island, are listed in Appendix 111 and presented graphically in Figures 10, 11, and 12. The CPUE data for the Eskimo Island location for 24 July have been included to provide temporal continuity of the sample dates and spatial continuity since the sample sites are presented east to west. CPUE values assume a great deal of variability due partially to the high variance associated with nearshore Arctic fishes and partially to the variance inherent in sampling different locations and consequently different habitat regimes. CPUE values for Arctic cisco reach their maximum on 28 July at Pitt Point with a smaller peak on 24 July at Eskimo Island. CPUE values for least cisco were greatest at Pitt Point and Black Head but relatively low elsewhere. Fourhorn sculpin, Arctic char and humpback whitefish CPUE values show a large degree of variation among locations but all species show peak abundance at either Pitt Point or Black Head or both. Broad whitefish show relatively small peaks at those two locations with their peak abundances occurring farther to the east at Tolaktovut Point and Garry Creek Inlet. Pink salmon first appeared at Pogik Point on 27 July when one green male was caught (Appendix 11). Peak abundances occurred at Pitt Point when 18 green adults were caught and at Black Head when 4 green and 12 ripe adults were caught. The first ripe adults were caught on 29 July at Drew Point. The mean size of males was 458.55 mm (fork length); females averaged 426.67 mm.

Figure 13 illustrates the pooled CPUE values for both anadromous and marine fishes. The pooled CPUE values for anadromous fishes show two major peaks, one at Pitt Point and the other at Black Head. The Pitt Point anadromous fish catches were dominated by Arctic and least cisco comprising 76.3% of the catch and the Black Head catches were

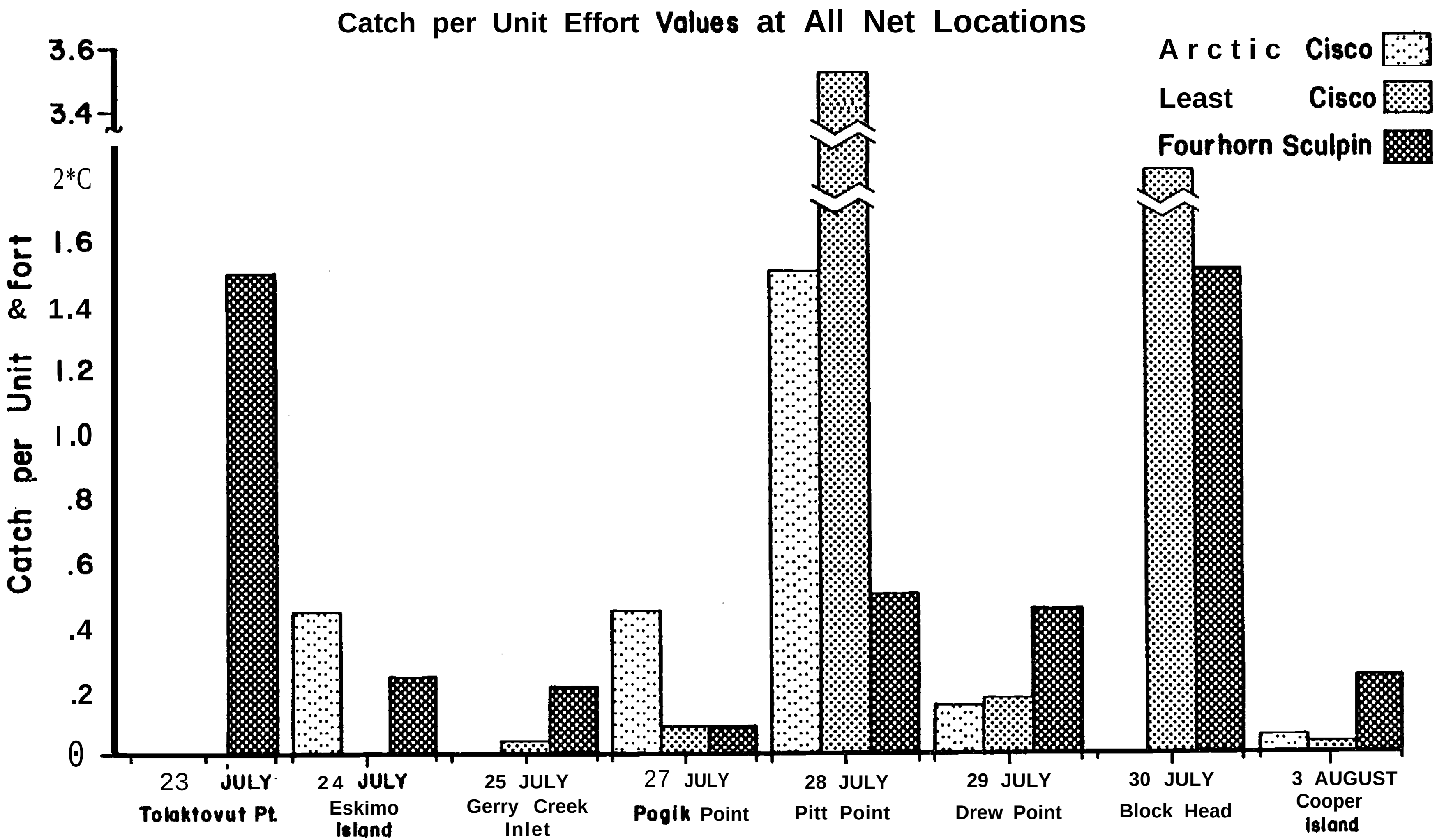

Figure 10. CPUE values for Arctic cisco, least cisco and fourhorn sculpin at all net locations. The catch at Eskimo Island on 24 July is used for continuity.

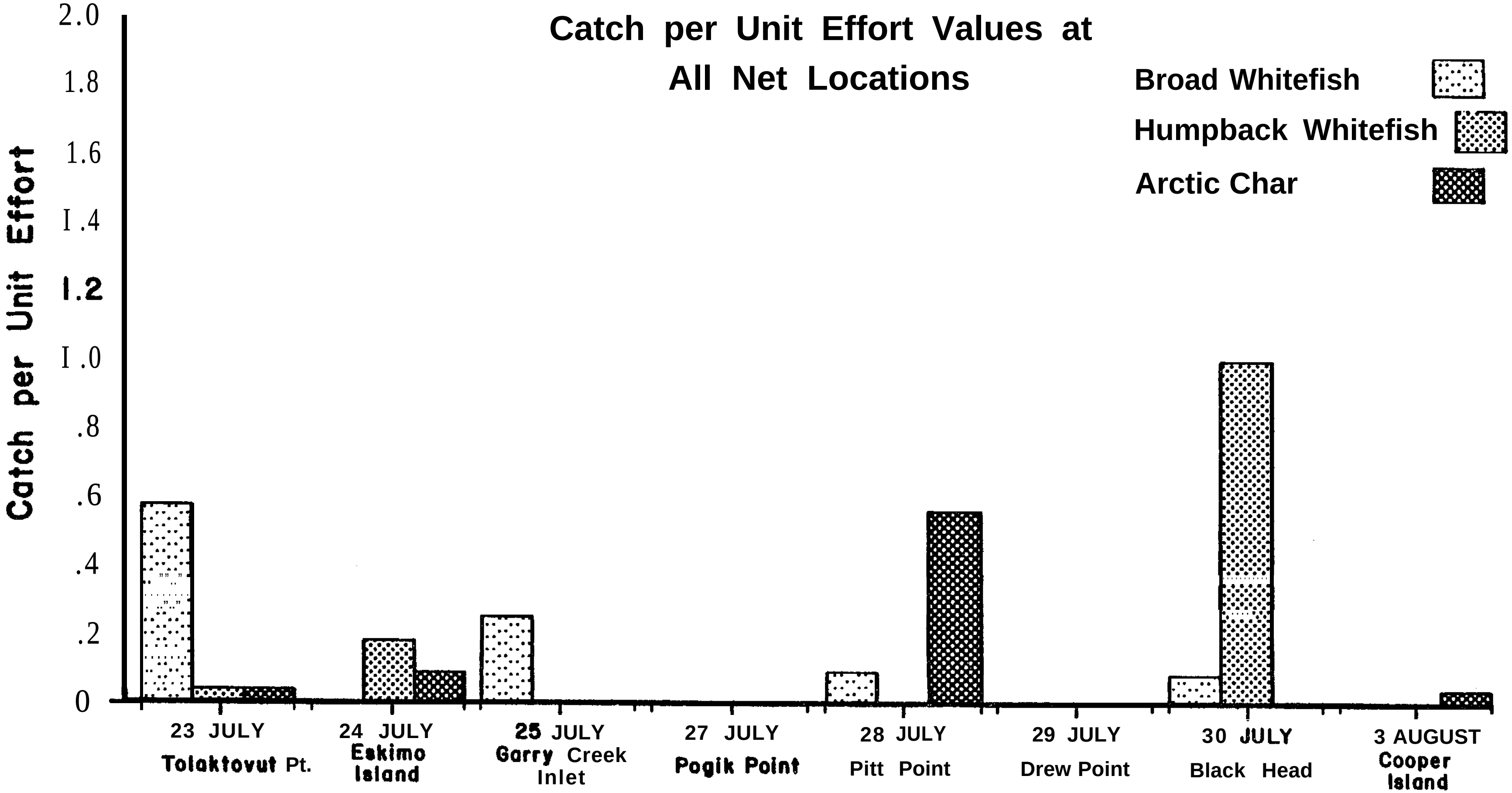

Figure 11. CPUE values for broad whitefish, humpback whitefish and Arctic char at all net locations. The catch at Eskimo Island on 24 July is used for continuity.

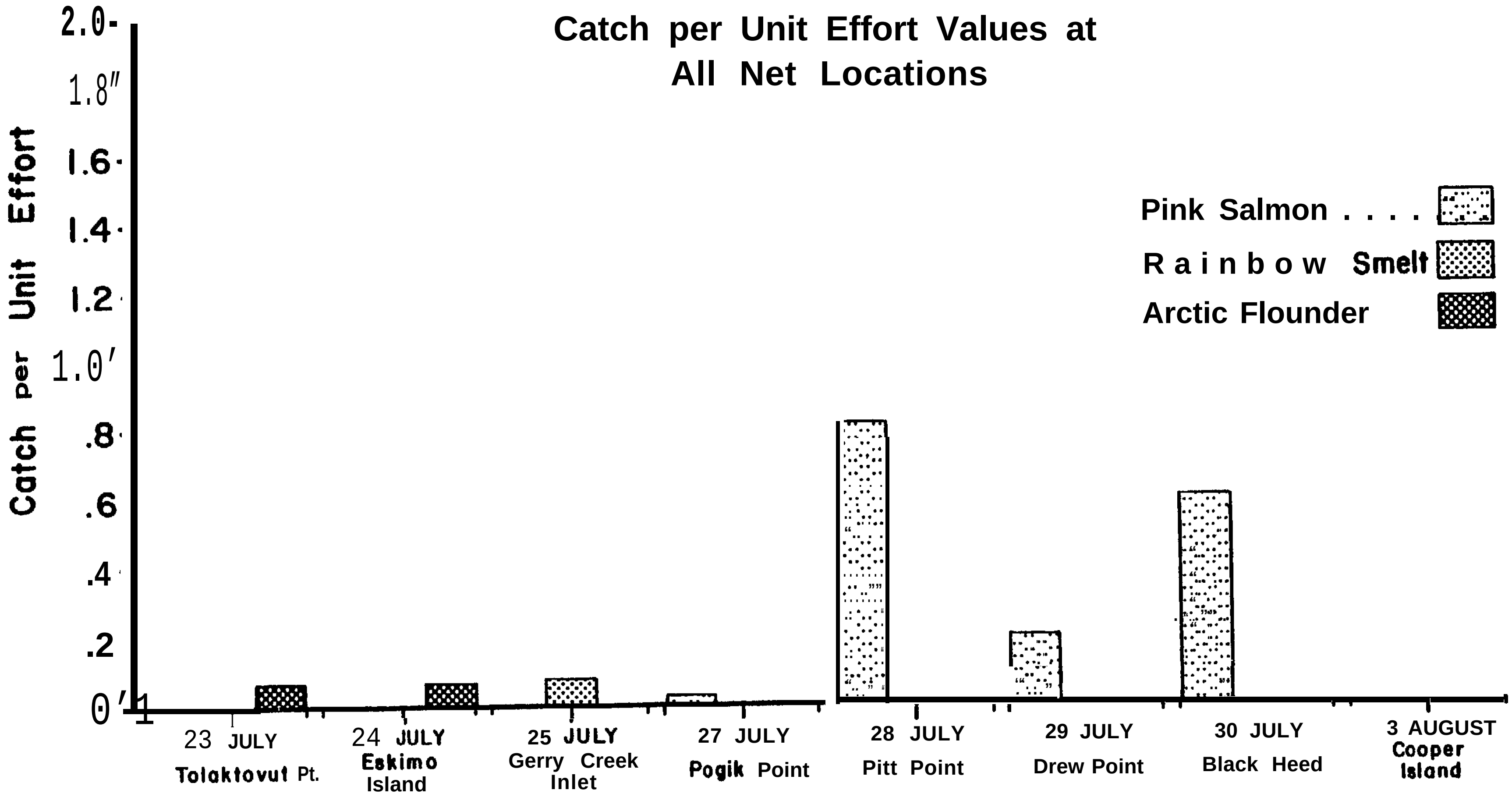

Figure 12. CPUE values for pink salmon, rainbow smelt and Arctic flounder at all net locations. The catch at Eskimo Island on July is used for continuity.

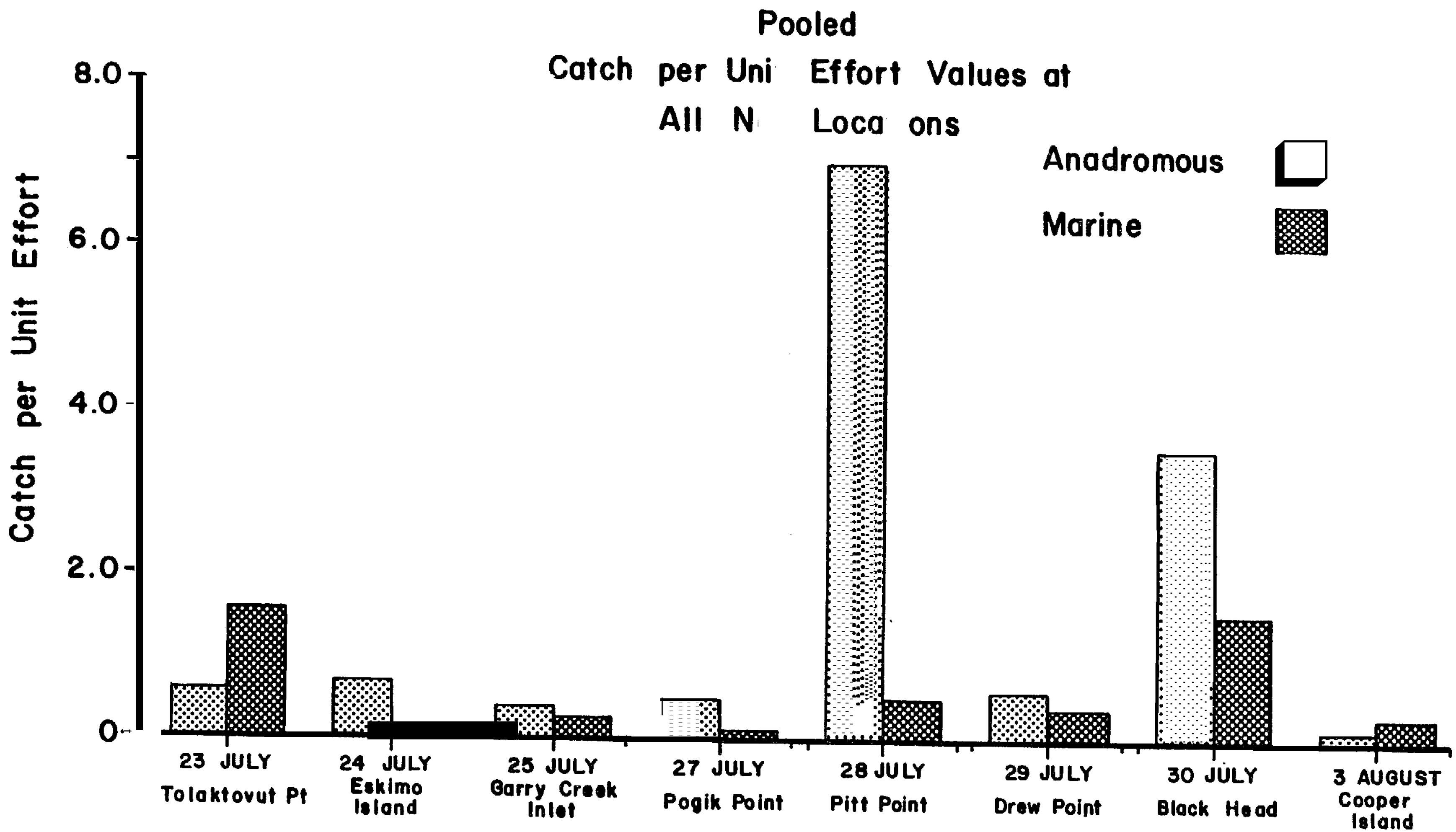

Figure 13. Pooled CPUE Values for anadromous and marine fishes at all net locations. The catch at Eskimo Island on 24 July is used for continuity.

dominated by least cisco and humpback whitefish comprising 81.3% of the catch (Table 1). Pooled CPUE values for marine fishes reach maximums at Tolaktovut Point and Black Head where fourhorn sculpin dominate the catches.

CPUE values for each species (except Bering cisco, round whitefish, capelin and saffron cod) were regressed separately upon temperature and salinity values at each station. The results including linear regressions, y intercepts and correlation coefficients are listed in Appendix V. None of the catches were significantly correlated with temperature or salinity illustrating the high variability usually associated with nearshore fisheries surveys (Craig and Haldorson 1981).

DISCUSSION

The species composition of catches along the Alaskan Beaufort coastline shows some degree of similarity as many of the same species continue to reappear in independent surveys. Species which tend to occur along the entire coast include the Arctic char, Arctic cisco, least cisco, fourhorn sculpin and Arctic flounder (Table 2).

The greatest disparity between catches of this and other studies occurs in the distribution and relative abundance of anadromous fishes, specifically among whitefishes. A greater number of whitefish species is found farther west along the coast as the distributions of broad and humpback whitefish are discontinuous east of the Sagavanirktok Delta, also the Bering cisco is believed to range only as far east as the Colville River. The relative abundance of Arctic cisco and Arctic char appears to decline from east to west as these fish represented greater percentages of the overall catch in virtually all studies conducted east of the present study.

The distributions of these anadromous fishes along the Beaufort Sea coast presumably reflects the east-west variation in physiography of the coastal regions and its subsequent effect on riverine habitat available for spawning, early life stages and overwintering. These physical differences in habitat type are largely a function of the proximity of

Table 2. A comparison of catch percentages by species of nearshore gillnet sampling along the Beaufort Sea coast (from Griffiths et al. 1975; Griffiths et al. 1977; Craig and Haldorson 1981; Griffiths and Gallaway 1982; Gallaway and Britch 1983; and Griffiths, LGL Ltd., pers. comm.)

Site Study (From West to East)	Present Study	Simpson Lagoon	Waterflood Causeway (Prudhoe Bay)	Sagavanirktok Delta	Kaktovik Lagoon	Angun and Beaufort Lagoons	Nunaluk Lagoon
Arctic cisco	17.1	56.3	28.7	44.3	19.8	37.1	55.6
Arctic char	2.4	14.2	39.6	17.7	9.6	37.8	21.1
Least cisco	28.5	11.6	21.4	12.2	1.5		2.5
Broad whitefish	3.1	3.8	0.2	13.3			
Humpback whitefish	5.4	2.2	0.1				
Bering cisco	0.2	1.0					
Rainbow smelt	7.7			0.2		0.7	
Pink salmon	4.2						
Coho salmon			0.1				
Chum salmon			*				
Round whitefish	0.2			0.1			
Arctic grayling							0.2
Inconnu							*
Fourhorn sculpin	29.6	9.2	9.4	11.6	67.8	24.1	18.9
Arctic cod		0.1	*	0.5	0.1		
Arctic flounder	1.4	0.4	*		0.5		1.5
Capelin	0.3	1.0			0.4	0.4	
Saffron cod	0.1		0.1	0.1			
Snail fish			0.1	0.1			
False sea scorpion					0.1		
n =	1201	781	2144	1577	729	278	1325

* = less than 0.1%.

the Brooks Range to the coast. To the east of the Colville River the continental divide (delineated by the Brooks Range) approaches to within 100 km of the coast, resulting in a relatively steep slope and narrowing of the Arctic Coastal and Arctic Foothills physiographic provinces (Payne et al. 1951). The streams of this region are typical of Mountain Streams as classified by Craig and McCart (1975). These fast-flowing, cold clearwater streams originate in the Arctic Mountain Province and are characterized by steep gradients, braided channels and spring sources are frequently associated with them. It is these which provide spawning and rearing habitat for Arctic char which Craig and McCart (1975) describe as the characteristic fish of Mountain and Spring Streams.

In contrast, west of the Colville River the continental divide lies 300 km from the coast. The gradual slopes of this region are drained by slow-moving, meandering Tundra Streams which are fed by tundra runoff from the broad Arctic Coastal and Arctic Foothills Provinces (e.g., Meade, Ikpikpuk and Topagoruk rivers). These rivers and associated coastal plain lake systems provide more suitable habitat for anadromous coregonids including the least cisco, broad and humpback whitefish.

It would follow that the two fish, Arctic char and Arctic cisco, more closely associated with features of the eastern coast would be more abundant in that area than in the west. The Arctic char associated 'with the mountain streams of the east coast and the Arctic cisco which is thought to reproduce only in the Mackenzie River are found to present a smaller percentage of the overall catches to the west. Concurrently, the three whitefish, humpback whitefish, broad whitefish and least cisco, which do not migrate as extensively and are more closely associated with the tundra streams of the western Beaufort coast represent a greater percentage of the overall catches to the west than to the east (where, indeed, the humpback and broad whitefish are not present in some collections).

The distribution of marine fishes shows a marked degree of similarity from east to west with the slight disparity among catches probably due to differential efforts and location of sample sites.

Fourhorn sculpin consistently dominate the nearshore catches, however, when high salinity, low temperature conditions persist toward the end of the open water season, there is often a large influx of Arctic cod (Griffiths and Gallaway 1982; Gallaway and Britch 1983). Other relatively abundant marine species found in nearshore catches are Arctic flounder, saffron cod, capelin and snail fish.

The length-frequency histograms for the two ciscos show a bimodal distribution especially in the case of Arctic cisco (Figure 3). This distribution is similar to the findings of Griffiths and Gallaway (1982). The small Arctic cisco size cohort captured during this study probably consists of a combination of age groups. Craig and Haldorson (1981) reported age 1 fish as having a mean length of 112 mm (range 65-145 mm) and age 2 fish as having a mean length of 155 mm (range 129-188 mm). The length-frequency histogram for least cisco also shows a small size cohort which corresponds to age 2 fish with a mean length of 126 mm (range 95-154) and age 3 fish with a mean length of 154 mm as reported by Craig and Haldorson (1981). The length-frequency histograms for the remaining species show no obvious size cohort segregation except for rainbow smelt. This species appears to have two size cohorts, one averaging about 175 mm, the other about 280 mm. Using the results reported by Craig and Haldorson (1981) the smallest cohort probably consists of age 3 through age 6 fish and the larger cohort consists of age 6 through age 15 fish.

Arctic char captured during this survey fell within the size range documented in other surveys along the Beaufort coastline, however, they were distinctly skewed toward the larger sizes. Gillnets generally have a sampling bias toward larger char as seen in the results of the Simpson Lagoon study (Craig and Haldorson 1981). Their gill net catches ranged in size from 180 to 720 mm while the catches of the present study ranged from 370 to 620 mm using gill nets of similar mesh. The reasons for this dispariy are unclear, however, one possible explanation may be that the Arctic char in the western" Beaufort are the larger members of the populations which are more capable of swimming greater distances from spawning and overwintering rivers to the east.

Catches at the Eskimo Island locations (Figures 5, 6, and 7) showed a high degree of variation both between species and between sample dates. This variation was not wholly unexpected since numerous other short surveys show a similar high variation. This variation may be confounded by a fishes temperature-salinity preference and by the seasonal timing of migration. During short surveys, such as the present study, these compound variables are difficult to completely separate, however, some patterns do appear. Considering only the Eskimo island catches, the CPUE values for Arctic cisco and humpback whitefish were significantly correlated with temperature and the CPUE values for least cisco and pink salmon were significantly correlated with salinity. The former correlation seems entirely reasonable in light of the recent experimental research done by Fechhelm et al. (1983) which showed a temperature preference of Arctic cisco to be about 15° C. Presumably humpback whitefish follow a similar preference, however, the critical experiments have not been done. The unexpected positive correlation of least cisco and pink salmon CPUE values may be due to a timing-of-migration effect rather than to temperature-salinity preference. This seems plausible at least for the salmon since the major migratory pulse of this species did not occur until 28 July, a time when salinities generally begin to increase at the end of the open water season (Appendix I).

Catches at the other net locations (Figures 10, 11, and 12) also show a high degree of variability and CPUE values for each species at all locations were not significantly correlated with either temperature or salinity (Appendix V). Aside from the previously discussed sources of variation, temperature-salinity preference and timing of migration, these histograms also reflect a locational variation where one site may be more or less favorable depending upon factors such as proximity to rivers or food resources, protection from turbulence and suspended peat sediments, etc. Protected areas where CPUE values were high (Black Head and to some extent Tolaktovut Point) may represent favorable habitat supporting larger densities of fish; on the other hand unprotected areas with high CPUE value (Pitt Point) may represent poor habitat through which fish were rapidly moving and consequently were being captured in large number. This dilemma can only be sorted out by employing either long term studies with passive gear (gill nets, fyke nets) or shorter term studies with active gear (trawls, seines).

Prospectus

Often when relatively new areas are investigated many questions arise from both the results of the investigation and from the experience of dealing with a new area. The western Beaufort is indeed a-new area, not merely an extension of the well-researched mid- and eastern-Beaufort coasts. It contains several habitats not represented in the east. The two large bays, Admiralty and Smith bays and the semi-enclosed bay, Harrison Bay, are unequaled elsewhere in the Alaskan Beaufort. The western Beaufort also contains a large lagoon, Elson Lagoon, and numerous tundra streams and rivers providing fish access to the numerous coastal plain lakes including Teshekpuk Lake, the largest in Arctic Alaska. The riverine systems that drain into the Beaufort differ, with montane streams to the east and tundra streams to the west. These differences may provide habitat distinctions which would presumably affect the distribution and abundance of the various fish species.

Observing these differences a list of research needs is presented. This list is based upon recognized" informational gaps and upon scientific curiosity. The list is presented below.

- The western Beaufort contains three large bays, Admiralty, Smith and Harrison bays, and a large lagoon system, Elson lagoon. What is the influence of riverine input on the temperature, salinity and turbidity regimes of these systems and how does this affect indigenous fish distribution and movements?

- What is the role of Teshekpuk Lake and other large tundra lakes in providing overwintering and spawning habitat for anadromous fishes?

- The distribution, timing of migration and abundance of several species of anadromous fish in the western Beaufort are poorly understood. Species included are Bering cisco, humpback whitefish and broad whitefish. Additionally, little is known of the distribution of out-migrating pink salmon smelt and subsequent juvenile stages spent in salt water.

- Little is known of the abundance of off-shore marine fishes or their distribution in relation to boulder patches or ice edges.

- Little is known of the temperature-salinity preferences of near-shore anadromous fishes. To date only one species, Arctic cisco, has been the subject of temperature-salinity preference studies (Fechhelm et al. 1983).

- What is the role of unprotected shoreline (e.g., Pitt Point) in influencing anadromous fish migration? Do fish migrate quickly through these areas or is there no difference between these and protected areas? How would causeway construction on unprotected shoreline affect local migration patterns.

- What will be the ramifications of cumulative industrial development upon near shore habitat, trophic dynamics and resource utilization including commercial and subsistence fishing?

ACKNOWLEDGMENTS

The authors thank Jim Helmericks who piloted the float plane, helped pick nets and offered freely his suggestions and his Arctic expertise. Without his help this survey would have strained to reach its objectives. We also thank Teena Helmericks and the younger members of the Helmericks family for their logistic and moral support.

Thanks is also extended to Rosa Meehan of the U.S. Fish and Wildlife Service for her assistance in picking nets and performing other odious tasks associated with fisheries surveys.

The completion of this report was facilitated by Evelyn Kimbrough who typed and helped edit the first draft, and Betsy Sturm who performed all the drafting and lettering.

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Appendix I. Temperature and salinity data. Physical data was taken when the net was set and again when the net was pulled. Both values are given along with the mean value.

Date	Location	Temperature (°C) In	Out	Mean	Salinity (ppt) In	Out	Mean
23 July	Tolaktovut Point	10.0	10.5	10.3	0	0	0
24 July	Eskimo Island	10.8	12.2	11.5	0	2	1
25 July	Eskimo Island	12.2	14.5	13.4	2	3	2.5
25 July	Garry Creek Inlet	11.2	12.0	11.6	2	2	2
26 July	Eskimo Island	11.5	9.5	10.5	3	2	2.5
27 July	Eskimo Island	9.5	10.0	9.8	2	2	2
27 July	Pogik Point	9.0	10.0	9.5	12	10	11
28 July	Eskimo Island	10.0	9.3	9.7	2	2	2
28 July	Pitt Point	9.0	4.0	6.5	5	18	11.5
29 July	Eskimo Island	9.3	7.0	8.2	2	5	3.5
29 July	Drew Point	4.2	4.3	4.3	19	16	17.5
30 July	Eskimo Island	7.0	9.2	8.1	5	2	3.5
30 July	Black Head	7.1	10.0	8.6	12	7	9.5
31 July	Eskimo Island	9.2	8.0	8.6	2	6	4
3 August	Eskimo Island	8.0	7.1	7.6	6	14	10
3 August	Cooper Island	4.2	8.0	6.1	29	24	26.5

Appendix II. Pink salmon capture data.

Date	Location	No.	Length	Sex	Condition
27 July	Pogik Point	1	440	M	Green
28 July	Eskimo Island	1	455	F	Green
		1	510	M	Green
28 July	Pitt Point	1	390	F	Green
		1	405	F	Green
		1	420	M	Green
		1	430	F	Green
		1	435	F	Green
		2	440	M	Green
		1	440	F	Green
		1	445	M	Green
		1	450	M	Green
		2	460	M	Green
		2	465	M	Green
		2	470	M	Green
		1	475	M	Green
		1	495	M	Green
29 July	Drew Point	1	435	M	Green
		1	460	M	Green
		1	475	M	Ripe
		1	475	M	Green
		1	495	M	Green
30 July	Black Head	1	380	F	Green
		1	410	M	Green
		1	430	M	Ripe
		1	435	M	Green
		1	435	F	Ripe
		1	440	M	Ripe
		1	445	F	Green
		1	445	M	Ripe
		1	445	F	Ripe
		3	450	M	Ripe
		1	460	M	Ripe
		1	475	M	Ripe
		1	490	M	Ripe
		1	495	M	Ripe
31 July	·Eskimo Island	1	450.	M	Ripe
3 August	Eskimo Island	1	420	F	Ripe
		1	440	F	Ripe
		1	440	M	Ripe
		1	445	M	Green
		2	460	M	Green
		1	495	M	Ripe

Males mean length = 458.55 mm, S.D. = 22.54, n = 38
Females mean length = 426.67 mm, S.D. = 23.39, n = 12

Appendix III. Survey schedule of net locations including species, number caught, percentage of catch, hours set and catch per unit effort (CPUE).

Date	Location	Species	No. Caught	% of Catch	Hours Set	CPUE
23 July	Tolaktovut Point	Humpback whitefish	1	1.7	25.75	0.039
		Broad whitefish	15	25.0		0.583
		Arctic char	1	1.7		0.039
		Round whitefish	1	1.7		0.039
		Fourhorn sculpin	40	66.7		1.553
		Arctic flounder	2	3.3		0.078
			60			
24 July	Eskimo Island	Arctic cisco	10	41.7	22.00	0.455
		Humpback whitefish	4	16.7		0.182
		Arctic char	2	8.3		0.091
		Fourhorn sculpin	6	25.0		0.273
		Arctic flounder	2	8.3		0.091
			24			
25 July	Eskimo Island	Arctic cisco	43	39.1	23.00	1.870
		Least cisco	18	16.4		0.783
		Humpback whitefish	11	10.0		0.478
		Broad whitefish	2	1.8		0.087
		Fourhorn sculpin	25	22.7		1.087
		Rainbow smelt	11	10.0		0.478
			110			
25 July	Garry Creek Inlet	Arctic cisco	1	6.7	23.25	0.043
		Least cisco	1	6.7		0.043
		Broad whitefish	6	40.0		0.258
		Fourhorn sculpin	5	33.3		0.215
		Rainbow smelt	2	13.3		0.086
			15			

Appendix III (continued)

Date	Location	Species	No. Caught	% of Catch	Hours Set	CPUE
26 July	Eskimo Island	Arctic cisco	27	31.4	19,50	1.385
		Least cisco	12	14.0		0.615
		Humpback whitefish	5	5.8		0.256
		Broad whitefish	2	2.3		0.103
		Arctic char	1	1.2		0.051
		Rainbow smelt	17	19.8		0.872
		Fourhorn sculpin	21	24.4		1.077
		Arctic flounder	1	1.2		0.051
			86			
27 July	Eskimo Island	Arctic cisco	21	46.7	23.50	0.894
		Least cisco	5	11.1		0.213
		Humpback whitefish	2	4.4		0.085
		Broad whitefish	1	2.2		0.043
		Arctic char	2	4.4		0.085
		Fourhorn sculpin	8	17.8		0.340
		Rainbow smelt	6	13.3		0.255
			45			
27 July	Pogik Point	Arctic cisco	10	66.7	23.00	0.435
		Least cisco	2	13.3		0.087
		Pink salmon	1	6.7		0.043
		Fourhorn sculpin	2	13.3		0.087
			15			
28 July	Eskimo Island	Arctic cisco	16	38.1	24.00	0.667
		Least cisco	10	23.8		0.417
		Humpback whitefish	4	9.5		0.167
		Arctic char	2	4.8		0.083
		Pink salmon	2	4.8		0.083
		Rainbow smelt	3	7.1		0.125
		Fourhorn sculpin	5	11.9		0.208
			42			

Appendix III (continued)

Date	Location	Species	No. Caught	% of Catch	Hours Set	CPUE
28 July	Pitt Point	Arctic cisco	33	20.8	21.25	1.553
		Least cisco	80	50.3		3.767
		Humpback whitefish	2	1.3		0.094
		Broad whitefish	2	1.3		0.094
		Bering cisco	1	0.6		0.047
		Arctic char	12	7.5		0.565
		Pink salmon	18	11.3		0.847
		Fourhorn sculpin	11	6.9		0.518
			159			
29 July	Eskimo Island	Arctic cisco	5	27.8	24.50	0.204
		Least cisco	6	33.3		0.245
		Humpback whitefish	3	16.7		0.122
		Broad whitefish	1	5.6		0.041
		Fourhorn sculpin	3	16.7		0.122
			18			
29 July	Drew Point	Arctic cisco	4	14.8	24.25	0.165
		Least cisco	6	22.2		0.247
		Bering cisco	1	3.7		0.041
		Pink salmon	5	18.5		0.206
		Fourhorn sculpin	11	40.7		0.454
			27			
30 July	Eskimo Island	Arctic cisco	4	16.7	27.50	0.145
		Least cisco	6	25.0		0.218
		Humpback whitefish	2	8.3		0.073
		Arctic char	1	4.2		0.036
		Rainbow smelt	5	20.8		0.182
		Fourhorn sculpin	5	20.8		0.182
		Saffron cod	1	4.2		0.036
			24			

Appendix III (continued)

Date	Location	Species	No. Caught	% of Catch	Hours Set	CPUE
30 July	Black Head	Least cisco	52	38.0	26.00	2.000
		Humpback whitefish	26	19.0		1.000
		Broad whitefish	2	1.5		0.077
		Pink salmon	16	11.7		0.615
		Fourhorn sculpin	41	29.9		1.577
			137			
31 July	Eskimo Island	Arctic cisco	8	3.0	75.75	0.106
		Least cisco	93	34.3		1.228
		Humpback whitefish	5	1.8		0.066
		Broad whitefish	6	2.2		0.079
		Arctic char	2	0.7		0.026
		Round whitefish	1	0.4		0.013
		Pink salmon	1	0.4		0.013
		Fourhorn sculpin	106	39.1		1.399
		Rainbow smelt	39	14.4		0.515
		Arctic flounder	10	3.7		0.132
			271			
3 August	Eskimo Island	Arctic cisco	18	13.9	28.50	0.632
		Least cisco	48	37.2		1.689
		Arctic char	2	1.6		0.070
		Pink salmon	7	5.4		0.246
		Fourhorn sculpin	43	33.3		1.509
		Rainbow smelt	9	7.0		0.316
		Arctic flounder	2	1.6		0.070
			129			
3 August	Cooper Island	Arctic cisco	5	12.8	98.50	0.051
		Least cisco	3	7.7		0.031
		Arctic char	4	10.3		0.041
		Fourhorn sculpin	23	59.0		0.234
		Capel in	4	10.3		0,041
			39			

Appendix IV. Linear regressions, y intercepts and correlation coefficients for CPUE values at the Eskimo Island location vs. temperatures and vs. salinity. Critical value at the 5% level is r = 0.666 and at the 1% level is r = 0.798, n = 9.

	Temperature	Salinity
Arctic cisco	slope = 0.2428 y intercept = -1.6465 r = 0.7620*	slope = -0.0360 y intercept = 0.8345 r = -0.1588
Least cisco	slope = -0.0771 y intercept = 1.3451 r = -0.2666	slope = 0.1682 y intercept = 0.0171 r = 0.8164**
Humpback whitefish	slope = 0.0687 y intercept = -0.5084 r = 0.9096**	slope = -0.0263 y intercept = 0.2495 r = -0.4895
Broad whitefish	slope = 0.0091 y intercept = -0.0495 r = 0.4075	slope = -0.0025 y intercept = 0.0491 r = -0.1814
Arctic char	slope =-0.0010 y intercept = 0.0584 r = -0.0503	slope = -0.0007 y intercept = 0.0515 r = -0.0507
Pink salmon	slope = -0.0190 y intercept = 0.2227 r = -0.4310	slope = 0.0272 y intercept = -0.0556 r = 0.8640**
Fourhorn sculpin	slope = 0.0092 y intercept = 0.5944 r = 0.0306	slope = 0.1262 y intercept = 0.2490 r = 0.5906
Rainbow smelt	slope = 0.0337 y intercept = -0.0219 r = 0.2241	slope = 0.0098 y intercept = 0.2709 r = 0.0921
Arctic flounder	slope = -0.0032 y intercept = 0.0692 r = -0.1194	slope = 0.0047 y intercept = 0.0219 r = 0.2486

Appendix V. Linear regressions, y intercepts and correlation coefficients for CPUE values for all net locations vs. temperature and vs. salinity for several species of fish. Critical value at the 5% level is r = 0.497, n = 16.

	Temperature	Salinity
Arctic cisco	slope = 0.0863 y intercept = 0.1084 r = 0.3292	slope = -0.0153 y intercept = 0.6442 r = -0.1841
Least cisco	slope = -0.1199 y intercept = 1.7900 r = -0.2795	slope = 0.0216 y intercept = 0.5624 r = 0.1587
Humpback whitefish	slope = 0.0297 y intercept = -0.1075 r = 0.2638	slope = -0.0044 y intercept = 0.1900 r = -0.1233
Broad whitefish	slope = 0.0208 y intercept = -0.1022 r = 0.3184	slope = -0.0077 y intercept = 0.1376 r = -0.3704
Arctic char	slope = -0.0155 y intercept = 0.2080 r = -0.2590	slope = 0.0021 y intercept = 0.0533 r = 0.1127
Pink salmon	slope = -0.0465 y intercept = 0.5476 r = -0.4228	slope = 0.0108 y intercept = 0.0549 r = 0.3087
Fourhorn sculpin	slope = 0.1095 y intercept = 0.4264 r = 0.1095	slope = -0.0114 y intercept = 0.7524 r = -0.1436
Rainbow smelt	slope = 0.0393 y intercept = -0.1776 r = 0.3517	slope = -0.0117 y intercept = 0.2568 r = -0.3312
Arctic flounder	slope = 0.0031 y intercept = -0.0020 r = 0.1655	slope = -0.0018 y intercept = 0.0389 r = -0.3057